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BROOD REARING BY HONEYBEES CONFINED TO A PURE CARBOHYDRATE DIET[1]

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In spite of the classical experiments of Huber (10), who concluded that bees cannot rear brood without pollen, many apiculturists are still arguing the question. Some of them have maintained that to a certain extent bees can produce brood when the stores are only sugar syrup (3, 6, 7, 11); others have claimed that it is wholly impossible (4, 5, 11). Both groups have supported these affirmations with reported observations.

Recently Whitcomb and Wilson (13) published a report in which they stated that colonies, composed of bees which were shaken onto new combs and fed only sugar solution, could rear brood; also a queen was produced.

Theoretically, the raising of brood without pollen, at least for a short period of time, would be possible if the proteins and the other materials of the bee tissues or the reserves deposited in special organs of adult bees could be converted into the larval food.

The present work was undertaken with the aim of finding a definite answer to the disputed question, and of gaining certain information on the value of the bees thus produced and on the changes that occurred in the bodies of the nursing bees.

METHODS.—During the years 1931–1932 two sets of preliminary experiments were undertaken. Essentially the technic used by Whitcomb and Wilson was applied. An outdoor colony of bees was placed in an isolated compartment of a greenhouse. For a certain period of time the bees were allowed to rear brood. Then the compartment was cleaned. The bees were shaken into a hive containing only frames with foundation. Sugar solution and water were given *ad libitum*. The bees built combs and started brood rearing. The latter continued for a

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period of two weeks. After that time the bees were able to raise larvae only until they reached the size of those two or three days old. Such larvae were then removed by the bees. When the queen was taken away, the bees failed to rear brood. Even the larva in a queen cell was eliminated by the bees after it was a day and one half old. Analogous results were obtained in the case of another colony treated in a similar way.

In order to gain further information it was necessary to use a colony in which all the bees were of approximately the same age. This colony was made up of young bees according to a technic already described (8). During three successive days emerging bees were brushed into a small hive containing combs with honey and pollen, and located in an isolated compartment. A fertile queen was added. The bees were allowed to develop and to rear brood in a normal manner. Weekly changes in weight and in the nitrogen content of the experimental bees were followed in the usual manner (9). The colony was examined every day and dead bees were counted. About a week after the first sealed cell was observed, the bees were transferred to a clean compartment and shaken into a small hive containing only newly built combs. Sugar solution and water were given to them in quantity. The queen laid eggs, and the bees fed the hatched larvae in the usual manner. However, the normal nursing activity continued for only one week. All larvae fed after that period were unable to reach maturity; they were removed by bees.

Ten days after the first sealed cell was observed the comb was removed from the colony and placed in a constant temperature chamber. The weights and the nitrogen content of the emerging bees were established in the manner already described (8).

RESULTS.—The following two tables represent the results of the experiment performed.

TABLE 1. AVERAGE NITROGEN CONTENT OF THE HEADS, THORACES, ABDOMENS AND WHOLE BEES AT THE BEGINNING OF THE PURE CARBOHYDRATE DIET AND AT THE END OF THE ACTUAL FEEDING OF THE LARVAE

	Nitrogen per bee in milligrams			
	Heads	Abdomens with digestive tracts removed	Thoraces	Bees with digestive tracts removed
Average initial value	.41	.47	1.69	2.61
Average final value	.39	.42	1.65	2.57
Milligrams lost	.02	.05	0.04	0.11
Percentage lost	5	11	2	4

TABLE 2. AVERAGE NITROGEN CONTENT OF HEADS, ABDOMENS, THORACES, AND WHOLE EMERGING BEES

	Nitrogen per bee in milligrams			
	Heads	Abdomens	Thoraces	Whole bees
Emerging bees from a normal colony in confinement	.27	.53	1.04	1.84
Emerging bees from the colony on pure carbohydrate diet	.27	.43	1.03	1.73
Difference	0	.10	.01	.11
Percentage less	0	18.9	.9	6.0

Table 1 shows that there was a loss in the average nitrogen content of all the parts of the bodies of the experimental bees, the greatest loss being in the abdomens.

Table 2 indicates that the average nitrogen content of all the parts (except heads) of the emerging bees raised by the colony on pure carbohydrate diet was smaller than that of those reared on a normal diet. The nitrogen content of the abdomens of the former was considerably lower than that of normal emerging bees.

DISCUSSION.—The experiments described clearly demonstrated that bees can rear their brood when fed pure carbohydrate diet. However, such an activity continues over a relatively short period of time.

The results obtained show that during the feeding period bees are using proteinaceous materials from all the parts of their bodies. Closer examination of the tables indicates that the greatest loss was in the nitrogen content of the abdomens of the experimental bees. This suggests that there is some organ or organs situated in that part of the body which may serve as a storage place for protein and that from this organ bees can draw materials in case of necessity.

It was noted by Koehler and confirmed by Snodgrass (12) that the fat cells of the fat body of wintering bees in January contain a large amount of protein material in the form of large granules, but that by spring they are mostly used up. The former author did not find stores of proteins in the fat cells during the summer months. This fact she explained by an assumption that the proteins are elaborated into the brood food as fast as they are produced in nursing bees.

The greatest percentage loss in the nitrogen content of the abdomens in our experiment could be explained by an assumption that there were considerable stores of proteinaceous materials in the fat bodies of the experimental bees which contributed in a large part to the production of the larval food and to the katabolic processes of the nurse-bees. Nevertheless, the heads and thoraces lost part of their nitrogenous materials, which signifies that they were also participating in supplying these materials for the above mentioned purposes.

Emerging bees from the carbohydrate colony contained less proteins than those reared by the colony which was fed a normal diet and kept under similar conditions. The fact that the abdomens of the former bees had a smaller amount of nitrogen was responsible for that phenomenon. These results are significant and suggest that nitrogenous materials can be stored in the fat cells of the fat body during the "prenatal" life provided that a food rich in proteins is used for the feeding of the nurse bees. The possibility that the ovaries of the emerging bees in the latter case are also more developed is not excluded (8). Boissezon (2) found that when mosquito larvae were reared on rich media, the resulting females could produce normal eggs without taking a blood meal, deriving all the materials necessary for egg formation from the stores deposited in their bodies during the larval life.

Since the number of bees in the colony during the feeding time was established and the number of young bees produced was ascertained, there is a possibility of calculating approximately the amount of nitrogen used for the rearing of a single bee.

Alfonsus (1) found that bees use 144.9 mgms. of pollen for the production of one worker bee. This amounts to about 4.67 mgms. of nitro-

gen. In our case every bee lost during the feeding period on an average 0.11 mgms. of nitrogen, the total for a colony, consisting of 2306 bees, being 253.66 mgms. Since 79 young bees were reared, the amount of nitrogen spent in rearing one individual was equal to 3.21 mgms. The average nitrogen content of an emerging bee was found to be 1.73 mgms. In other words, 1.48 mgms. of nitrogen was spent in the katabolism of the nursing bees and larva—an amount about equal to the total nitrogen of the emerging bee produced. The greater value ascertained in the work of Alfonsus is undoubtedly due to the fact that more nitrogen was katabolised in the digestive processes, as well as to the possibility of some protein materials being voided with the excreta.

Conclusions

1. Adult bees can rear their brood when fed a pure carbohydrate diet. Brood rearing in this case continues for a relatively short period of time.
2. For the production of the larval food, bees can use materials from their own body tissues, preferably those of the abdomen.
3. The nitrogen content of the heads and thoraces of the emerging bees reared by the colony on pure carbohydrate diet did not appreciably differ from that of the emerging bees produced by a colony which had been fed a normal diet under the same conditions. However, the nitrogen content of the abdomens was considerably lower in the former case.
4. About as much nitrogen was used in the katabolism of the nurse bees and immature instars as was contained in the emerging bees which resulted.

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THE WILLOW WEEVIL AS A DECIDUOUS FRUIT INSECT PEST

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The possibility of insects occurring on native, economically unimportant plants becoming serious pests in orchards is well demonstrated in a study of the introduction of the willow weevil, *Stamoderes*[1] *uniformis* Casey, into the fruit districts of Sonoma County, California. Known as a native of the willow along the banks of the Russian River for many years, this insect has within the past ten years acquired new hosts and has firmly established itself in the deciduous fruit orchards adjoining the river. For at least five years the damage had been severe and in several areas the loss had exceeded fifty per cent of the crop. The orchardists confusing the damage with that of tussock moth, *Hemerocampa vetusta* (Bdv.), were ineffectively attempting control when the investigations were taken up by the University of California in the spring of 1928.

The history of this insect dates back to 1888 when it was taken by Casey (1) on willow below Duncan's Mills, California. He described a male and noted that "the female was more robust, with prothorax slightly more transverse and the elytra much more strong inflated." Several years later (1896) Dr. E. C. Van Dyke collected it on willows above Guerneville and has on several occasions taken it on willow near the same locality. The first specimens to be collected from apple orchards were taken by the author in 1927 about five miles north of Sebastopol. This infestation covered an area of approximately twenty-two acres and had undoubtedly been there many years as the beetle population was very heavy. Since 1927 an almost continuous chain of infestations have been found from the nearest point on the river to the west side of Sebastopol—a distance of approximately eight miles.

The practice of some of the orchardists of this section of cutting willow props along the river banks to be used in their orchards to support limbs heavy with fruit, undoubtedly explains how many of the infestations started. These props were cut in the early summer at the time of the year when the adult weevil and egg masses were most abundant. Though the beetles do not fly they do play "possum" and drop when even slightly disturbed and in this way are undoubtedly easily transported through an orchard when disturbed by a passing team and wagon or tractor. They have been observed to travel over ploughed ground some distance though this means of distribution is rather slow. It is significant that no native growths of willow adjoining any orchard infested with the weevil have been found to have an infestation of the beetle.

Though willow is apparently the only native host along the river bank, in the orchard it has been taken on apple, pear, peach, cherry and prune. Apple undoubtedly is the preferred host of the orchard group and the Gravenstein variety has shown the heaviest injury.

[1]Now Mimetes Schonherr and therefore this species becomes *Mimetes uniformis* (Casey). Van Dyke, Edward C. Pan. Pac. Ent. XI, 2, pp. 83–96, April 1935.

LIFE HABITS.—The adults begin to appear the first few warm days of March and emerge from the ground about the base of the tree when the apple buds are beginning to show the "green tip" stage and continue to emerge until April. The beetles feed on the tender tips of folded buds, blossoms and newly formed fruit. Then when the fruit is set and growing the attack continues and deep gouges are cut on the sides of the green fruit damaging it much as does the tussock moth or leaf roller. These markings may heal over but in most all cases the scars are so deep and large that the fruit cannot be graded as anything but "culls."

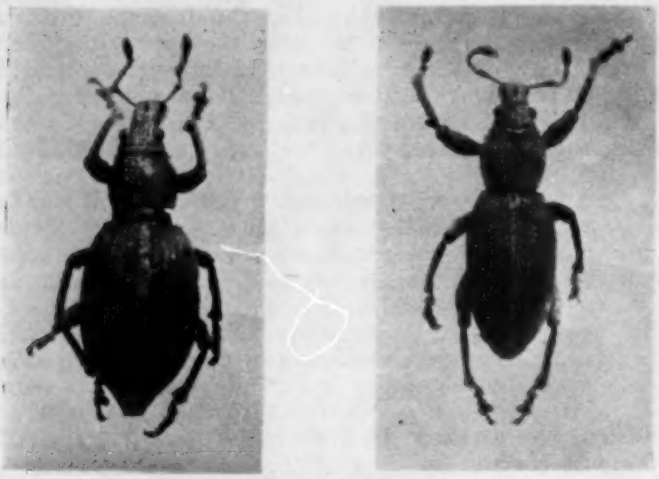

FIG. 96.—Willow weevil, left female, right male.

Along in late April or early in May the black egg masses are found on the undersides of the leaves. The eggs are deposited side by side in two nearly parallel rows and are white at first but within from five to seven days turn to glossy black. To each egg is attached a pedicle almost twice as long as the egg and it is by this that the egg is attached to the leaf. The outer end of each pedicle is bent to the left and laps over the end of the pedicle of the egg previously deposited. In this way the tips of the pedicles form the attachment and the eggs lie side by side and are suspended by the pedicles. They are 1 mm. long by .4 mm. wide, nearly cylindrical with both ends elliptical, the chorion or covering membrane is particularly tough, smooth, glossy black. A count of the eggs in thirty-five egg masses gave from ten to 52 eggs with an average of twenty-five eggs per mass.

Egg deposition continues until about the middle of June when all adults disappear. The eggs hatch in from eighteen to twenty-one days depending upon the temperature and the white larvae soon drop to the soil and disappear to feed on the roots of its host until the pupation period over the winter months.

CONTROL DEMONSTRATION.—Following the heavy loss of fruit in 1928, amounting to more than fifty per cent of the crop, a block of apples in the center of one of the heaviest infestations was chosen as a control area. It included approximately twenty acres of Gravenstein and late variety apples with a small block of Bartlett pears. About ten marginal rows were left as a check though these trees were not nearly as heavily infested as were those in the control area.

FIG. 97.—Egg cluster of willow weevil.

FIG. 98.—Damage to apples by willow weevils.

In late February the rough bark was scraped from each tree to be treated and a six inch band of ordinary white shellac was applied to the trunk or scaffold limbs to receive the tanglefoot. It was thought the shellac would prevent too deep penetration of the soft bark though in later work the shellac was omitted without injury. Early in March, just after the first beetles began to appear, the bands of tree tanglefoot were applied using a two and one-half inch wooden paddle. This gave a thin band approximately one-eighth inch thick and about three inches wide. Care was taken to fill all irregularities in the bark under the band and to secure an even continuous band around the trunk or limb. It was later found that it was necessary to go over all the tanglefoot bands once every two weeks to freshen them up and prevent them from becoming foul with petals, twigs, dirt or insects. Some extra material was required each time over as just rubbing a paddle over the original tanglefoot did not leave the band in the best condition.

The beetles were effectually stopped by the bands. A very few attempted to wade through the "sticky" material and were usually caught unless the temperature was low enough to make the tanglefoot comparatively firm or it had become foul with dust or other foreign matter.

One fortunate thing is that when the temperature is low and the band is apt to become somewhat firm the activity of the beetles is decidedly lessened. On cold windy or wet days they seek cover in the ground or under bark scales. On warm days they are very active but the tanglefoot also becomes very viscous. It was also noted that the majority of the beetles on approaching the band are apparently deterred by its odor for they stopped about half an inch below the band and either followed the lower margin around the tree trunk or returned to the ground.

As soon as the beetles began to appear in numbers below the bands tests were made to determine the best means of destroying them. Blocks of from twelve to sixteen trees were treated with different poisoned baits and observations made on feeding habits and the number of dead beetles found at the base of the trees after one day, two days, a week and two weeks time. The baits used were:

1. Poisoned bran mash with ground apple.
2. Ground apple with acid lead arsenate.
3. Dried apple dipped in acid lead arsenate.
4. Apple twigs dipped in acid lead arsenate.
5. Dried apple dipped in Paris Green solution.
6. Willow twigs dipped in Paris Green solution.

The results of the test are tabulated below:

Bait number	Number trees	Average number of dead beetles after one day	two days	one week	two weeks
1	12	1	4	6	6
2	16	2	4	6	6
3	16	6	12	16	30
4	12	5	6	8	8
5	12	10	16	29	50
6	16	20	41	182	304

The poisoned bran mash, ground apple and apple twigs quickly dried out and the beetles ceased feeding on them after three or four days. The dried apples were fairly good though after the beetles had fed through the covering of poison their toxic effect was lost. The willow twigs, twelve to fifteen inches long, remained green for several days and the beetles continued to feed on them even after they had wilted.

Dusting experiments with 7x Nicodust, pyrethrum, sulfur, and sodium fluosilicate on the infested trunks below the bands did not give satisfactory results even on the warmest days.

As there was an abundance of willow sprouts available the poisoned willow twigs were used throughout the remainder of the adult insect season (April to June). The willow bait had to be replaced about every ten days with new bait. The method of preparing the bait was as follows: twigs from willow sprouts (from twelve to fifteen inches long with plenty of foliage) were cut and tied about the center into convenient sized bundles. Each end of the bundle was dipped into a three gallon solution of Paris green. The solution was prepared by adding one quarter pound caseinate spreader to three gallons of water and then adding about two pounds of Paris green while constantly stirring. After dipping, the bundles were opened and spread out and allowed to dry on an old prune tray. When dry the bundle was carefully collected and carried out into the field on a sack. One or two twigs, depending

upon the size, were placed in the crotch of each tree, if the bands were above the crotch. It is preferable if possible to band the trees just above the crotch as this makes it possible to place the bait close to the band and where the beetles congregate.

Towards the end of May the beetles rapidly diminished and by the 10th of June none could be found in the orchard excepting the dead ones at the base of each tree. The care of the bands and the feeding of the poisoned bait was discontinued on the above date.

As a test of the ovicidal value of summer oils against the eggs of this beetle, a separate block was sprayed with 1 per cent, 1 and ½ per cent, 2 and 3 per cent solutions in the orchard and separate lots of eggs dipped in these solutions were kept in the insectary. In all cases there was a normal hatching of the eggs.

That the banding effectively kept the beetles from damaging the fruit was proven by several large checks made from fruit out of the control area. Three truck loads of apples from different parts of the control area were carefully sorted and one hundred boxes from the marginal check rows. In the 15,000 pounds of fruit from the check area only 130 pounds showed beetle injury while from the 475 pounds taken from the control area 160 pounds were graded as culls. The few beetles that had got up in the tree before the banding was completed (March 22nd) and any that may have crossed the bands did not cause enough damage to be noticed after usual thinning of the apples in the spring.

In the spring of 1929 all the bands on the control area were refreshened and feeding of the poisoned willow began on April 14th. The control area was widened to cover all the marginal infestations. There was only a small percentage of the beetles in 1929 as compared to 1928 in the control area and by May 20, 1929 practically every live beetle had disappeared. The 1929 crops showed practically a hundred per cent control.

This area has been under observation for the past three years and though there has been little or no damage to the fruit crop a light infestation still occurs. Following the year 1929 but little attention was given to the banding and practically no baiting done. It was found that where the adult females below the bands were not poisoned they would occasionally deposit eggs under bark scales and in this way the infestation persisted. Too frequently the orchardists neglect control practices as soon as the loss from attack has reached a low mark.

Though these tanglefoot bands have been on these tree trunks for five years there is no apparent damage. In some cases the old bark with its coating of tanglefoot has loosened from the trunk but under it is another healthy layer of bark and cambium.

The introduction of this pest into our commercial orchards is just another instance of an insect leaving a non-important native plant, changing its food, and becoming a serious pest doing tremendous damage to valuable crops. It not only exemplifies the fact that we must be on the lookout for such occurrences but also the value of knowing the native host plant so that more effective control may be obtained.

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BIOLOGICAL NOTES ON *ATAENIUS COGNATUS* (LEC.), A NEW PEST OF GOLF GREENS IN MINNESOTA (SCARABAEIDAE—COLEOPTERA)[1]

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On July 13, 1932, Doctor A. A. Granovsky and the writer were requested to inspect a grub infestation present on one of the local golf courses. A survey of certain parts of the course showed that a small scarabaeid grub was causing considerable damage by killing the grass here and there on the greens and fairways. Diggings made beneath these deadened areas of grass to ascertain the number of individuals and stages of this pest, which was subsequently identified as *Ataenius cognatus* (Lec.), were very productive. For example, one six inch square sample yielded 29 grubs, 8 pupae, and one freshly emerged adult. Another sample digging about ten inches square revealed 42 grubs and 29 pupae. All stages of the beetle were most abundant immediately below the turf, and, although some stages were taken deeper in the soil, neither grubs nor pupae penetrated the soil farther than five inches vertically. According to the caretaker, one of the badly infested greens had been treated with arsenate of lead on July 5th; nevertheless, several adult beetles were subsequently reared from grubs and pupae obtained from this same green on July 13th.

LITERATURE REVIEW.—Forbes (1905) records taking this species from wet, decaying husks of a fallen ear of corn at Farina, Illinois, and that another specimen emerged July 23rd from a pupa found among corn roots on the 21st. Blatchley (1910) states that *Ataenius cognatus* (Lec.) hibernates in large numbers in dry cow dung and beneath it, and that it flies during warm sunny days in winter. He also mentions that it frequents fungi and is attracted to electric lights. In a later paper (Blatchley, 1928), he records finding this species by the hundreds in Florida beneath piles of decaying *Chara* and weed debris along ditches.

LIFE HISTORY.—Field observations coupled with the fact that the writer was able to keep adults alive in the laboratory at 25° C from September to January definitely show that this species overwinters only in the adult stage. At St. Paul, Minnesota, the beetles have been taken in the University light trap as early as May 1st, and it is likely that the females oviposit in late May or June, because only full grown or nearly mature grubs were obtained in diggings made July 13th. In the laboratory a number of these grubs were isolated in salve tins and jelly glasses, the bottom half of the containers being supplied with a mixture of milorganite (a commercial fertilizer often used on golf courses) and soil, which in turn was topped with a piece of sod. As soon as the grubs attained their full growth they excavated cells in the soil within which they passed a short prepupal period. Under laboratory conditions the mean duration of the pupal period, based upon 15 specimens, was 8.7 days (minimum 7 days, maximum 11 days), all of the adults emerging on or before August 27th. On September 1, 1932, Mr. E. C.

[1]Paper Number 1311 of the Scientific Journal Series of the Minnesota Agricultural Experiment Station.

Murdoch and the writer made several diggings at the golf course but failed to find any stages of this scarabaeid present. However, upon examining some waste piles composed of milorganite and grass cuttings from the greens, a large number of adult beetles awaiting winter were found in the moist parts within the upper six inches of the heaps. Thus, there is apparently only one generation a year in Minnesota.

Description of Stages

Larva.—Mature *Ataenius cognatus* (Lec.) grubs measure approximately 8.5 mm. in length and 1.8 mm. in width. The head capsule, which is largely light brown in color, measures about 1.3 mm. in length and .75 mm. at its greatest width; epicranial suture visible; four-segmented filiform antennae; clypeus subquadrate; labrum smaller than clypeus, narrowed at base, with a row of short setae on the extended central anterior margin; apical half of well-developed mandibles dark brown or black, right mandible bidentate, left mandible tridentate; maxillary palpus three-segmented; tip of galea setose; row of prominent setae on inner margin of lacinia.

Thoracic legs tawny; remainder of body white in color, sparsely clothed with short and long fine tawny hairs; anus transverse, dorsal and ventral anal lobes swollen; radula composed of several short rows of strong recumbent setae on each side of middle line.

Prepupa.—This stage is easily recognized because the grub is rather inactive and there is a definite shortening of the body, the loose integument gathering in folds at the anal end. The absorption of the larval legs is very noticeable near the close of the prepupal stage.

Pupa.—The pupae of this species are approximately 4.7 mm. long and 2.1 mm. wide across the base of the wings. Newly-emerged pupae are entirely white. In older pupae the head, thorax, and wings are rufo-testaceous, while the abdomen is white on the dorsum and tawny on the venter. The prominent clypeal protuberance is unbonate on the caudal margin; margin of pronotum greatly thickened, broadly scalloped, disk minutely umbonate; dorsum of each abdominal segment with an elevated integumentary fold, caudal extremity of abdomen furcate with spiniform points.

Distribution.—Leng (1920) lists *Ataenius cognatus* (Lec.) from New England, Indiana, Florida, Arizona, and New Mexico. Records obtained from specimens in the entomological collection of the University of Minnesota indicate that this species also occurs in Ohio, Illinois, Minnesota, Missouri, and Texas.

Control.—In order to prevent a serious attack of these beetles on golf courses, green-keepers should insist upon the proper disposal of all grass cuttings and excess fertilizer, and should never permit the accumulation of such materials in heaps beside the greens. The refuse should be removed at least twice a week to a distant compost heap where, if scattered thinly enough, it will dry rapidly and thus become unsuitable for the development not only of this scarabaeid but of the common house fly as well.

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SOME RECENT ADDITIONS TO OUR KNOWLEDGE OF THE BIOLOGY OF THE PEA WEEVIL

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The investigations conducted by the Bureau of Entomology, U. S. Department of Agriculture, on the control of the pea weevil (*Bruchus pisorum* L.) continue to yield new and interesting facts in connection with the life history of the insect. Some of the information points definitely to fallacies in early recommendations, already known to be inadequate, for the control of this insect.

Hibernation of the Adult Weevils.—It was formerly thought that fumigation of all harvested peas would control the pea weevil. Whitehead (*6*)[1] pointed out that the failure of this method of control might be due to the fact that the weevils overwintered in the field and infested the next year's crop. Larson has already reported (*3*) that weevils escaping from peas left on the ground after harvest form the most important source of infestation in the Willamette Valley in Oregon and the Palouse area of Idaho and Washington. They have been found hibernating in all sorts of trash adjacent to and on the pea fields. Larson and Hinman (*4*) observed that the bark of pine and numerous other trees, moss, lichens, liverworts, cracks in fence posts, and hedge row debris all harbored hibernating weevils. Severe infestations and local centers of serious infestation can almost always be readily traced to the availability of one or more of these hibernation materials. It has been repeatedly observed (*5*) that the heaviest infestation in a field is almost always on the side adjacent to wood lots, pine-covered hills, or outbuildings.

Weevil Abundance Influenced by Winter Temperatures.—Where the temperature does not fall below zero Fahrenheit and where snow covers the hibernating weevils during cold weather they are able to survive in large numbers. However, when the winter temperature drops far below zero large numbers of the weevils die. To learn something of the temperatures that weevils could survive in protection similar to that afforded by cracks in fence posts and buildings, hibernation cages were placed in 52 localities in Oregon and Idaho during the winter of 1932–33. All weevils in these cages were killed in localities where the temperature dropped as low as —10° F. However, in cages protected by grass and snow some weevils survived in localities where the air temperature had been as low as —23° F. It is apparent from the results of this experiment that the relative immunity from weevil damage of some of the pea-growing districts in the upper Snake River country and in certain parts of northern Idaho and Montana is probably due to the low minimum temperatures often recorded in these localities.

Survival of the Pea Weevil Through Two Winters.—The pea weevil develops within the pea from eggs laid on the outside of the green pod. Under favorable conditions many of the weevils emerge

[1]Italic numbers in parentheses refer to Literature Cited, p. 670.

soon after the peas have been harvested. When temperatures are lower they remain inside the harvested peas. Early writers assumed that weevils remaining in these peas could not survive two winters in hibernation and emerge.

A series of experiments conducted through 1931, 1932, and 1933 at Moscow, Idaho, in which weekly examinations were made of peas stored under warehouse conditions showed quite a considerable number of these weevils surviving a second winter. Examinations showed 11 per cent of these weevils still alive on May 27, after passing through two winters. The weevils were active when examined. One of them laid 467 eggs—more than were laid by any other weevil under observation at the Moscow laboratory in 1933. One of the weevils from this 1931 crop was still alive and was placed in hibernation in November 1933.

Large Numbers of Eggs Laid.—The pea weevil has never been reported in the literature as being a very prolific egg layer. Korab (*2*) reported the largest total number of eggs laid by one female to be 222. The present writers found that some individuals lay many more eggs. In 1932 one female at the Moscow, Idaho, laboratory laid 735 eggs over a period of 84 days (*1*). Another, in 1933, laid 749 eggs at Corvallis, Oreg., over a period of 113 days. Not all the eggs were fertile, however, in either of the lots mentioned above. A maximum of 56 eggs in 1 day was recorded at the Moscow laboratory in 1932.

Oviposition in the Field.—Korab (*2*) reported that the oviposition period of the weevil is very short. In the field this is usually the case and is caused by the disappearance of the blooms after a few weeks, as any one planting of peas soon passes through the blossoming period. Individual plantings of peas have been shown to be suitable for oviposition for from 8 to 30 days. When regular weekly plantings were made, providing a continuous supply of blossoms for food and pods for oviposition, egg laying continued over a period of 11 weeks at Moscow, Idaho, in 1933.

Partial Second Generation Observed.—The possibility of a partial second generation was demonstrated at the Corvallis laboratory when two recently emerged females laid 26 eggs before being put into individual cages and then laid 140 and 144 more eggs, respectively, after being separated. These eggs, although the females were paired with males that had emerged at the same time, were not fertile. However, in a third such pair of weevils the female laid 76 eggs, 7 of which were fertile. These and other weevils that oviposited in the laboratory had gone through their complete cycle—egg to adult—during the summer of 1933. A partial second generation was also noted at the Moscow laboratory.

Injury to Pea Pods by Adults.—The adult weevils feed principally on the pollen of the pea flower but also on the pollen of other plants. The writers have found that in some varieties of peas they make feeding punctures in the pods. Where the infestation is heavy this sometimes results in a loss because of mis-shapen and poorly developed pods.

PEA WEEVIL PARASITES.—Two parasites, *Microdontomerus anthonomi* Cwfd. and a new species of *Eupteromalus*, were reared from peas infested with the pea weevil at Moscow and Corvallis.

CONCLUSIONS.—The ability of the weevils to live and lay viable eggs after the second winter spent in hibernation shows that the recommendation to hold seed over 1 year is not entirely adequate. The ability of the weevils to lay eggs before hibernating and the long oviposition period when blooms are available may be of great importance where successive crops of early and late peas are produced in the same section during a summer. The fact that they may lay several hundred eggs over a long period of time also has an important bearing on any control method that may be outlined.

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A PRELIMINARY REPORT ON THE RESPONSE OF THE EUROPEAN CORN BORER TO LIGHT[1]

By G. E. R. HERVEY and C. E. PALM, *New York State Agricultural Experiment Station, Geneva, N. Y.*

During the season of 1933 an experiment dealing with the response of the European corn borer (*Pyrausta nubilalis* Hübner) to light was under the observation of the writers at Charlotte, Monroe county, N. Y. The experiment was conducted in two fields of Golden Bantam sweet corn comprising slightly over one acre in each and in which six light-traps were installed per field. Daily records of the moth catch were made as well as an examination of the stalks and ears at harvest for records of the infestation. The data obtained in this experiment are presented here as a preliminary report on the response of the corn borer to light.

DESCRIPTION OF EXPERIMENT.—The plan of the two fields and the distribution of the several lights is shown in Figure 99. The corn in Field No. 1 was planted April 27 and that in Field No. 2 on May 16.

The insect traps used were of the electrocuter type, as shown in Figure 100, and were equipped with 75 watt type A Mazda lamps as a source of illumination. The traps were suspended from a cross arm on

[1]Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 41, May 1, 1934.

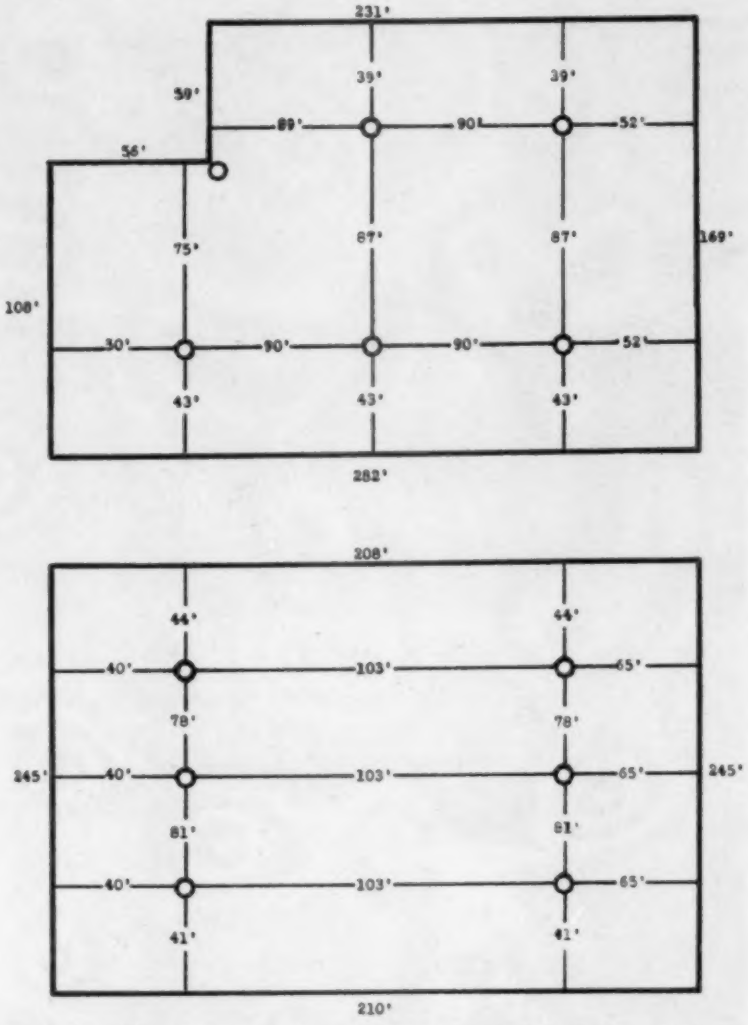

FIG. 99.—Plan of the experimental fields and the distribution of the light traps. *Above*, field No. 1. *Below*, field No. 2.

a pole by means of a rope and pulley so that they could be raised or lowered to any height desired. When the moth flight commenced the traps were suspended about eight or ten feet from the ground, but it was soon found that the catch was much greater when they were lowered to a point level with the top of the corn. The traps in both fields were in operation from June 11 to August 8. The lights were on from 8:15 P. M. until 4:00 A. M. and were controlled by a time switch.

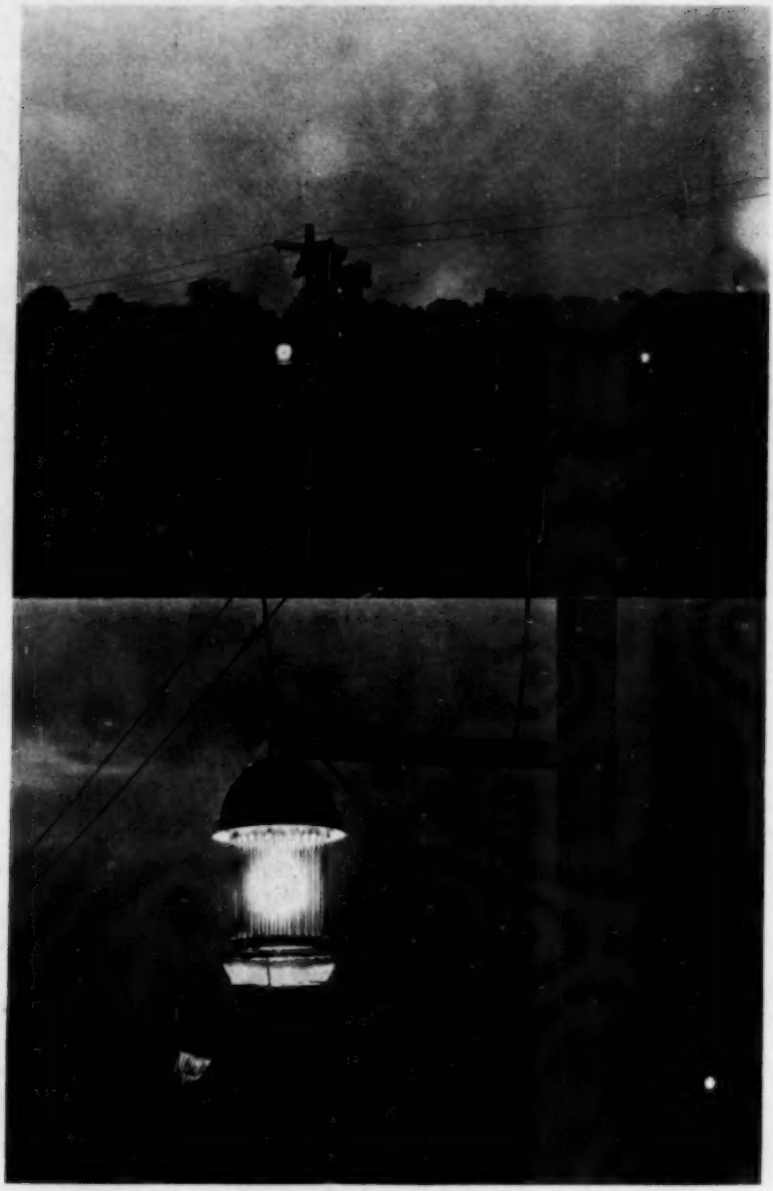

FIG. 100.—*Above*, general view of one of the lighted fields. *Below*, the insect trap used in the experiments.

RESULTS OF EXPERIMENT.—The distribution of the moth catch is shown in Figure 101 and Table 1.

TABLE 1. THE NUMBER AND SEX RATIO OF MOTHS TAKEN IN EACH FIELD AND THE TOTAL CATCH IN BOTH FIELDS

	Females	Males	Total
Field No. 1	303	221	524
Field No. 2	185	146	331
All traps	488	367	855

The moth flight extended from June 21 to August 1, altho the number of moths taken after July 20 was relatively small. Bi-daily examinations of infested stubble and other debris at several points in the vicinity of Rochester indicated that the emergence of the moths was completed in the field on July 24.

There appears to be a rather definite relation between the mean temperature from 8:00 P. M. until 4:00 A. M. and the number of moths caught in the traps. This is shown in Figure 101 and Table 2.

TABLE 2. THE AVERAGE NUMBER OF MOTHS CAUGHT PER NIGHT IN ALL TRAPS AT DIFFERENT TEMPERATURE RANGES

Temperature range degrees F. 8 P.M.–4 A.M.	Number of nights	Number of moths caught	Average caught per night
70–75	5	312	62.4
65–70	9	229	25.4
60–65	10	144	14.4
55–60	4	9	2.3

The data taken after July 19 were not included in Table 2 because the number of moths caught was small and hence there was little or no correlation between catch and the temperature. It is quite apparent that mean night temperatures between 70 and 75 degrees were the most favorable for the flight of the insect. At mean temperatures below 70 the average moth catch per night dropped off rather rapidly, and below a mean of 60 the activity of the insect was much retarded.

While the moth flight in the field started at dusk, it was usually the case that few moths were taken in the traps before 10:00 P. M. The majority of the catch was made between 10:00 P. M. and midnight, with an occasional moth up to 2:30 A. M.

The response of the corn borer moths to the type of light used did not appear to be strongly positive. For example it was commonly observed that they would fly by the lights at only a few feet distance with apparently no indications of any response to the illumination. In other instances it was noted that the moths would alight on a corn leaf near the trap, remain there for several minutes and then fly away from the light.

EFFECT OF LIGHT TRAPS ON THE CATERPILLAR POPULATION IN THE Fields.—The infestation records of the two fields are shown in Table 3.

TABLE 3. THE INFESTATION RECORDS IN THE TWO FIELDS UNDER OBSERVATION

	Number stalks examined	Per cent infested	Number ears examined	Per cent infested
Field No. 1	500	41.8	2331	23.6
Field No. 2	500	27.4	——	——

No satisfactory means was found for determining the possible value of the lights as a control measure against the insect. To compare the infestation in these fields with the infestation in other fields in the vi-

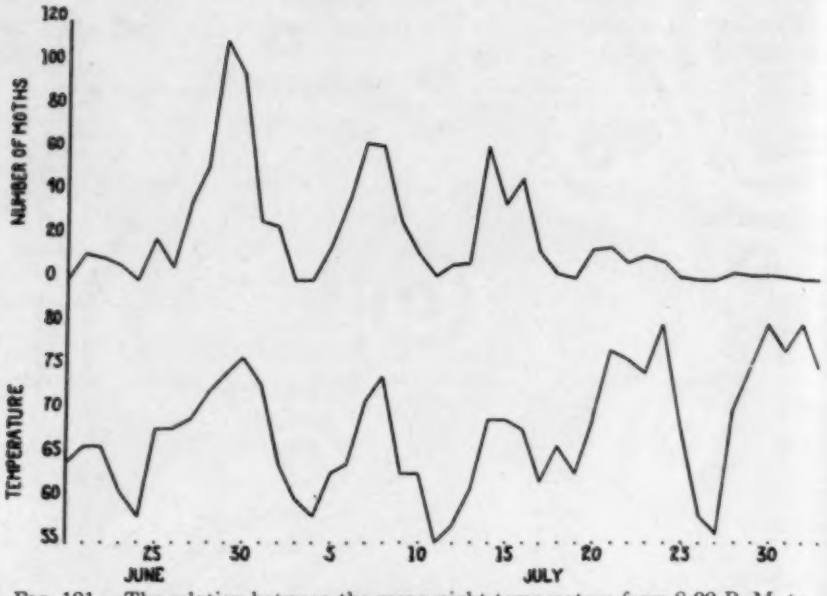

FIG. 101.—The relation between the mean night temperature from 8:00 P. M. to 4:00 A. M. and the number of moths caught in the traps.

cinity may give an approximate estimate. However, owing to the natural variations in infestation introduced by such factors as planting dates, location, soil, vigor of the corn and others, such comparisons are unsatisfactory. It appeared that the infestation in the lighted fields was essentially the same as in more or less comparable fields in the general Rochester area. It was noted that invariably the infestation was highest in the vicinity of the lights. An examination of the stalks in the hills adjacent to the lights and in successive hills up to seven rows away indicated that the infestation dropped off rather rapidly. The counts made in this examination are as follows: The hills in the row immediately surrounding the light 84.6 per cent infested, 2nd row 62.7 per cent, 3rd row 50.0 per cent, 5th row 39.3 per cent, 6th row 37.8 per cent. Various explanations may be advanced to explain this fact. It is possible that the moths may prefer the twilight conditions in the vicinity of the lights for oviposition rather than the total darkness in the remainder of the field.

SUMMARY.—Light traps of the type tested under the conditions governing the experiment appear to have little value in protecting sweet corn from the corn borer. Substantial moth catches were made over a period of 42 days and over half of the specimens were females. The infestation developing in the experimental fields, however, was apparently an average infestation for that general area.

The traps appear to have value as a means of studying the habits of the insect, particularly the period of flight, flight habits and the effect of weather conditions on the activities of the moths.

It is possible that with a different arrangement and number of lights or a different light source the moth population in the field might be lowered sufficiently to reduce the normal larval population. However, the number of moths captured under the conditions of the experiment reported here must have represented only a small part of the moth population of the field.

INSECTARY STUDIES ON THE LONGEVITY AND PREOVIPOSITION PERIOD OF THE BLUEBERRY MAGGOT AND ON CROSS BREEDING WITH THE APPLE MAGGOT

By L. C. McAlister, Jr., and W. H. Anderson,[1] *Bureau of Entomology and Plant Quarantine, United States Department of Agriculture*

Most investigators who have studied the life histories of both the apple maggot and the blueberry maggot—biological forms of the same insect, *Rhagoletis pomonella* Walsh—have encountered serious difficulties because the adults do not behave normally in captivity. Illingworth (*3*)[2], O'Kane (*6*), and Porter (*7*) have described their difficulties in connection with the apple maggot, and Lathrop and Nickels (*4*), studying the blueberry maggot, reported that "The difficulties encountered in rearing specimens of this species in confinement have prevented cross rearing and other experiments which might assist in solving the question of specific identity. In the absence of experimental rearing, other means must be used in examining this problem." For this reason information concerning the preoviposition period and certain other details of the life history, which usually can best be obtained with insects under close observation in captivity, has been inadequate. Methods of control, however, have been established, based on the reasonably accurate information on the life cycle of this insect obtained by field observations.

Fluke and Allen (*2*) were able to keep 306 captive flies of the apple maggot alive and in an apparently normal condition for an average of approximately 32 days. They found that the flies could be maintained thus for the longest period on a "solution consisting of one to three per cent yeast in five per cent honey water." This solution was placed in small vials, and a wick of blotting paper inserted so that one end extended beyond the lip and served as a feeding surface.

Feeding Method.—In their work on the blueberry maggot, the present writers have successfully used a modification of Fluke and Allen's method of feeding. The flies were kept in cylindrical celluloid cages 1½ inches in diameter and 5 inches long, with cheesecloth at each end to permit a circulation of air. Strips of blotting paper about 4 inches long and ¾ inch wide were saturated with the feeding solution and inserted in the cages. The feeding solution and blotting paper

[1]Field assistant at the Cherryfield, Maine, laboratory of the Bureau of Entomology during the summers of 1930, 1931, and 1932.

[2]Numbers in parentheses refer to the Literature Cited at the end of this paper.

were replenished daily, for it was early determined that if one feeding was omitted many of the flies died within a day or so; moreover, fermentation was believed to be detrimental to the flies.

In addition to the solutions of 1 to 3 per cent of yeast (compressed yeast cakes) in water containing 5 per cent of honey with which Fluke and Allen had had success, a solution of yeast alone, one of honey alone, and also water alone were used in the feeding tests. In 1932 cut blueberries were also used. In 1931 tests were carried out both in the insectary and out of doors, but in 1932 all the cages were kept in the insectary.

By this method the writers have been able to study (1) the longevity of adults, (2) the length of the preoviposition period, and (3) the possibilities of interbreeding the apple maggot and the blueberry maggot.

ATTRACTION OF THE SOLUTIONS.—The flies were slightly attracted to the honey and the honey-yeast solutions. When a droplet of either of these solutions was placed within one half inch of the flies, they immediately faced toward it, extended their probosicides, and began to lap up the solution. If the droplet was placed between ½ inch and 1½ inches from the flies, they turned toward it but did not attempt to feed. At greater distances the attraction was much less, for only occasionally did a fly respond.

LONGEVITY OF ADULTS.—The results of the longevity studies, in which 920 blueberry-maggot flies were used, are given in Table 1.

TABLE 1. LONGEVITY OF FLIES OF THE BLUEBERRY MAGGOT WHEN GIVEN DIFFERENT FEEDING SOLUTIONS, CHERRYFIELD, MAINE, 1931 AND 1932

Season	Feeding solution	Flies	Length of life		
			Minimum	Maximum	Mean
		Number	*Days*	*Days*	*Days*
1931	3 per cent yeast + 5 per cent honey	75	2	33	15.4
	2 per cent yeast + 5 per cent honey	277	3	25	12.2
	5 per cent honey[1]	88	6	23	10.6
	No food[1]	42	2	7	4.4
	3 per cent yeast[1]	13	2	9	3.8
	1 per cent yeast + 5 per cent honey[1]	36	1	15	2.8
	Water alone[1]	13	1	7	2.3
1932	3 per cent yeast + 5 per cent honey	75	3	47	25.8
	3 per cent yeast + 5 per cent honey[2]	203	2	33	11.8
	Cut blueberries	6	7	13	10.7
	5 per cent honey	27	3	10	4.1
	Water alone	27	3	7	4.0
	No food	58	1	4	2.1

[1]Run out of doors; all other series run in the insectary.

[2]The flies in this series were kept in galvanized-wire cages, and it is believed that many were poisoned by particles from the wire. Most of the flies died with distended abdomens, showing that they were well fed.

It is obvious that the flies lived longest when fed the honey-yeast solution. In 1932 several flies fed on the solution of 3 per cent of yeast and 5 per cent of honey lived more than 40 days and one fly lived 47 days, whereas the flies fed the 5 per cent honey solution lived an average of only 4.1 days, indicating that honey alone is not a suitable form of food.

The average length of life of flies fed the solution of 3 per cent of yeast and 5 per cent of honey compares favorably with the length of life of flies observed in the field by Lathrop and Nickels (5). The present writers, using the methods described by Lathrop and Nickels, observed

the length of life of flies in the field to be about 19 days in 1931 and about 23 days in 1932.

Both in the insectary and out of doors, direct hot sun was found to be very disastrous. If the flies in cages were left in the sun, unprotected by shade, for only a few minutes, high mortality resulted.

PREOVIPOSITION PERIOD.—The preoviposition period of both the blueberry maggot and the apple maggot has been difficult to determine exactly. Porter (*7*) used large numbers of flies of the apple maggot in many different types of cages, but the flies rarely oviposited. The preoviposition period of the flies that laid eggs ranged from 13 to 32 days. Porter also dissected a large number of flies that had been maintained in captivity throughout their lives, and he concluded that "in most cases the development of the eggs was proceeding very slowly or not at all. This abnormal behavior of the flies in captivity leads one to doubt the value of preoviposition records obtained under such conditions." O'Kane (*6*) found preoviposition periods of 4, 6, and 8 or more days, but very few eggs were laid in his extensive series of experiments. Other investigators who have tried to determine the length of the preoviposition period either have obtained varying results or have failed entirely. Porter (*7*) says of the apple maggot that "The best that can be done on the basis of the unsatisfactory and conflicting evidence available is to hazard the guess that under field conditions in early summer the preoviposition period may be at least a week."

The results of the two seasons' work show that the average length of the preoviposition period is about 13 days. In 1931 the preoviposition period as indicated by the first-observed eggs laid in 24 cages, utilizing 143 male flies and 160 female flies, ranged from 6 to 16 days, with an average of 11 days. In 1932, with 21 cases of observed first oviposition, utilizing 37 male flies and 78 female flies, the period averaged 15.7 days, ranging from 6 to 21 days. These results are in agreement with observations made by Lathrop and Nickels (*5*) that the average preoviposition period is about 12 or 13 days.

INTERBREEDING.—Several investigators consider that the apple maggot and the blueberry maggot are separate species. Lathrop and Nickels (*4*) state that "from an ecological viewpoint the two forms of *R. pomonella* are distinct and independent." Curran (*1*) has separated the two forms into distinct species on the basis of morphological differences in the male genitalia, and has described the blueberry maggot as *R. mendax*. It is apparent, however, that these two forms have arisen from the same species, although how far the separation has porgressed is still open to question.

In an attempt to determine whether or not the apple and the blueberry strains of *Rhagoletis pomonella* would interbreed, 10 unfertilized females of each strain were confined separately with males of the opposite strain. Mating occurred in every case between the blueberry males and the apple females, but was observed less commonly, in 3 cases, between the apple males and the blueberry females.

No eggs resulted from the cross of the apple males on the blueberry females, but one blueberry female that had been cross-bred was ob-

served to go through the process of oviposition several times. It was impossible to determine whether or not she laid any eggs, but if so they were evidently not fertile because no maggots resulted. In the cases of the cross of the blueberry males on the apple females, eggs were deposited in blueberries by 7 cross-bred apple females. The eggs hatched into 17 maggots, and from the maggots 15 puparia apparently normal in size for the apple maggot were obtained. The work on the blueberry maggot in Maine was discontinued in the fall of 1932, and unfortunately no adults were reared from the puparia.

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FIELD STUDIES OF *THRIPS TABACI* LIND. WITH ESPECIAL REFERENCE TO RESISTANCE IN ONIONS

By H. A. Jones, S. F. Bailey, and S. L. Emsweller, *California Agricultural Experiment Station, Davis, California*

A review of the literature on the onion thrips and its control shows that, progressively, with the development of economic entomology and chemical control measures, nearly all insecticides have been employed at one time or another with little but transitory success. This minute insect presents a difficult problem for many reasons, chief of which are its large number of hosts, its parthenogenicity and overlapping generations, its lack of natural enemies, its adaptability to a wide range of climate, and its manner of living in a protected "micro-environment."

As regards host resistance, very little work has been done on this phase of thrips control. Wardle, Simpson, and MacGill (1927) state that *Thrips tabaci* prefers the lower side of the cotton leaf as a result of a difference in epidermal thickness and MacLeod (1933) classifies many of the common varieties of onions as resistants, average, and susceptibles, based on the numbers of thrips present.

Field Study of Thrips Populations on Various Types of Onions.—It has been a common observation among growers who have had an opportunity to compare different varieties growing side by side, that

the Sweet Spanish types are somewhat more resistant to thrips injury than varieties like Australian Brown and Southport Yellow Globe. It has been suggested that the supposed resistance of the Sweet Spanish types is not real but only apparent because of their late maturing habit. In order to understand more clearly the nature of this observed difference in varieties it was necessary to have a definite knowledge of the number of thrips on the plants under field conditions.

In this study, made during 1933, forty-four varieties and strains of onions, including foreign plant introductions, were employed. Each plot was made up of ten plants of each variety and the plots replicated five times. Each group of ten plants was considered as a unit and the mean number of larvae per plant of each variety was calculated from the field counts made at five-day intervals. All varieties were compared with the White Persian which showed a marked resistance and had a mean number of larvae per plant of only 4.14 ± 0.09. The difference in the mean number of larvae per plant of the White Persian and all other varieties was significant (Jones, Bailey and Emsweller).

History and Characteristics of the White Persian Variety.—In an effort to develop varieties of onions resistant to pinkroot, smut, mildew, and thrips, we have been chiefly interested in securing introductions from countries of Western Asia, especially the area from Palestine to India because it is to this region that De Candolle assigned the probable native home of the onion. It is in this region then that we would expect to find the greatest diversity of form and perhaps discover some character that would help resist the insect pests and diseases that attack this crop under cultivation.

The White Persian variety was obtained by Dr. W. E. Whitehouse of the United States Department of Agriculture, Division of Foreign Plant Introduction, while he and H. L. Westover were on an exploration trip through Europe and Asia Minor in 1929. A number of varieties were collected in Persia, but according to Dr. Whitehouse the peasants were of the opinion that a large white onion grown under irrigation in Kashan, a village situated in the hills about 3,000 feet above sea level, was the best in Persia. Seed of this variety was distributed from Washington as FPI 86279 and later was given the name of White Persian by the California Agricultural Experiment Station.

Three crops of bulbs have now been grown from the seed originally obtained from Persia, and one crop from seed grown at Davis.

The foliage is of light green color, the leaf blades are round in cross-section, and the waxy bloom is almost absent. The plants are late maturing and have an open, spreading type of growth. The bulbs are white in color, oblate, and the very peculiar flavor is exceptionally mild. The bulbs are soft, have a tendency to split badly, and do not keep well in storage. The tendency to bolt is very strong (capacity to flower the first year at the expense of bulb production).

The most important use for this variety at present, it would seem, is to hybridize it with the existing important commercial types and incorporate in them the characters that give resistance.

Nature of Resistance.—The characters in the White Persian vari-

ety which appear to be most important in regulating the resistance are the open, spreading type of growth, the nearly circular leaves (in cross-section), the thickness of the leaf tissue, and the color of the leaves.

The open type of growth and the circular structure of the leaves seem to offer a minimum of hiding places for the thrips and result in a low population. The "silvering" or scarring resulting from the feeding of the thrips does not appear to penetrate so deeply on the leaves of the White Persian as on other varieties. The thickness of the leaf tissue may have an important bearing on this difference since measurements have shown that the White Persian has the thickest leaf tissue, the Sweet Spanish an intermediate thickness, and the Australian Brown the thinnest. Also it is thought that the leaf color may be a factor contributing to the degree with which the plants are able to withstand injury since it is known that dark green plant tissues absorb more light and consequently are subjected to higher temperatures than the lighter colored tissues at high environmental temperature (Harvey, 1924). In this connection, it may be noted that the White Persian has leaves of a light green color, the Sweet Spanish type, an intermediate shade, and the Australian Brown group, a dark green.

BREEDING FOR RESISTANCE.—An effort is now being made to incorporate the factors for thrips resistance into susceptible varieties by crossing with White Persian. The method of inheritance of these characters will be presented later in another paper. At the present time F_2 and back cross generations are being grown in the field and in the greenhouse.

The first crosses between White Persian and other varieties were made by intermingling. Seed of the White Persian was sown and from among the seedlings it was possible to select the F_1 plants because of their darker foliage color. Some of the F_1 plants were selfed; others were back crossed to commercial types.

It is felt that the progress made in attempting to solve one of the most difficult problems of onion production has been fundamental. The results are so promising that future control measures may be greatly simplified.

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PHYLLOXERA DEVASTATRIX PERG.[1] ON PECANS

By HOWARD BAKER, *Assistant Entomologist, Bureau of Entomology, U. S. Department of Agriculture*

Certain species of phylloxera have been known as pests of pecans for many years. They have appeared intermittently in great numbers, have remained seriously abundant for a few years, and then generally have sunk back into the obscurity from which they arose until they were again favored by conditions suitable for their rapid development.

Although phylloxera have been reported as attacking pecans throughout the pecan belt, they are most frequently reported causing serious damage in Louisiana, Mississippi, and Texas. In these States several species of phylloxera have been reported as responsible for damage, but one of these, *Phylloxera devastatrix* Perg., appears to be by far the most important.

In Louisiana *P. devastatrix* has been found to confine its attacks largely to the varieties Stuart and Schley and, occasionally, Success. It may attack any part of the current season's growth, including shoots, leaf and leaflet stems, leaves, and nuts. In instances of severe infestation the trees attacked, at the height of gall development and immediately thereafter, often appear on the verge of death, although, in every instance that has been noted, they have recovered. In addition, limbs are devitalized and frequently killed, twigs are malformed, devitalized, and killed, foliage is lost, and nuts attacked are deformed and drop, while nuts growing on attacked twigs are likely to drop prematurely or fail to fill properly. It is likely that this species, if it were able to maintain a heavy infestation over a period of years, would cause the death of many trees or injure them to the point where they would be of little value. As it is, trees may suffer severely from a single season's infestation when it is a heavy one.

In Louisiana the young nymphs of *P. devastatrix* begin to appear in the spring from the first to the middle of April on the unfolding buds, where each inserts its beak, commences feeding, and is soon enveloped in a gall formation. Records of new gall formation indicate that the nymphs appear in large numbers over a period of from 2 to 3 weeks, after which time they continue to appear for an additional period of from 1 to 3 weeks, depending upon seasonal conditions and the continued presence of new, tender growth. In Louisiana practically all the galls appear during April. The galls increase in size as the family within grows and develops. The galls vary widely in size and shape; the greatest diameter of mature ones ranges from about one eighth to five eighths of an inch, while their shape varies from a more or less globular one to that of an irregular mass, depending upon whether they grow singly or in a crowded condition. In a heavy infestation the galls are frequently so numerous that they form an irregular mass in which the separate galls are indistinguishable. As the galls develop they are

[1]Determined by Dr. P. W. Mason, Bureau of Entomology.

green to yellow green in color, with an occasional immature one showing a tinge of red. Mature galls turn brown or black and soon dry up.

The gall-building member develops to maturity within the gall and deposits eggs therein in large numbers. These eggs hatch into young nymphs that develop into mature winged forms within the gall. Thirty galls were examined to determine the number of individuals developing within them. The small galls contained from about 350 to 500 specimens each, medium sized ones from about 500 to 800 each, and large ones from about 800 to 1,100 each. The maximum number of specimens found developing within any one gall was 1,300, the minimum was 315, and the average for the entire lot was 740.3. Parasites are usually numerous and may destroy all or a portion of the individuals within a gall. When a portion, but not all, of the winged forms within a gall reach maturity, the gall splits open transversely into several sections and releases them. The first galls split open about 3 to 4 weeks after the appearance of the nymphs on the unfolding buds, and by late May or mid June, depending upon seasonal conditions, all that are to develop to maturity have done so and opened.

Almost immediately after leaving the gall, the winged forms begin to deposit eggs on the limbs, twigs, and leaves in the vicinity of the gall from which they emerged. The length of life of these winged forms is very short, few living more than 2 and none more than 3 days after emerging from the gall. In 1932, 100 specimens lived an average of 1.88 days each, while in 1933, 100 specimens lived an average of only 1.68 days each. In 1932, 145 individuals deposited an average of 11.58 eggs each, while in 1933, 100 individuals deposited an average of 11.47 eggs each. Most of the eggs were deposited during the first day following emergence of the winged forms from the gall. Weather conditions influenced the number of eggs deposited; one group of 50 individuals deposited an average of 18.68 eggs each during a period of ideal weather conditions, while a group of 45 individuals deposited an average of only 3.24 eggs each during a period of cool, rainy weather. Most other groups deposited about the average number of eggs, as given for the total number of specimens on which observations were made, or about 11 eggs per individual. In 1932, 72.54 per cent of 397 eggs hatched in an average of 5.59 days each, the first ones hatching on the fifth day after deposition and the last ones on the eighth day. In 1933, 87.63 per cent of 590 eggs hatched in an average of 5.40 days each, the first ones hatching on the fifth day after deposition and the last ones on the tenth day.

The minute forms hatching at this time (late May or early June) are greenish yellow tinged with black. They soon mate and then search for a sheltered place. They are little in evidence on rough-barked limbs at hatching time but may be so numerous on the upper smooth-barked ones as to cover them almost completely. On such limbs they are almost invariably found crawling downward, apparently in search of suitable winter quarters. On the older trees they congregate in large numbers under pieces of bark, under old covers of the obscure scale, in crevices—in fact, in or about almost any place offering some protection to them.

On young trees having no rough bark they have been observed to congregate about the trunk at the ground level, later dispersing to trash, such as old dried leaves, sticks, etc., on the ground near the trunk. Shortly after mating a single egg forms within the body of each female of this generation, after which they soon die with the eggs still in their bodies. A close examination of 200 individuals of this generation, which turn a dull reddish brown soon after their death, showed that 144 (or 72 per cent) of them contained the single egg. The remaining 28 per cent were presumably males, although this fact was not determined. There is no further development during the summer, fall, winter, and until the eggs hatch at or about the time the buds begin opening the following spring.

Only a small percentage of all galls formed are able to develop to maturity and open, some simply failing to develop, others being crowded out, and others being destroyed in whole or in part by parasites. Some idea of the part played by parasites in the natural control of this species may be ascertained from the following data: In the late spring of 1931 infested twigs and branches, taken from orchard trees carrying a heavy infestation of *P. devastatrix*, were placed about a caged Stuart tree on the laboratory grounds. As a result of this infestation 68 galls developed on this tree in 1932, of which only 6, or 8.82 per cent, reached maturity, while 34, or 50 per cent, were destroyed by parasites. The parasites themselves were destroyed by the writer before they reached maturity, with the result that in 1933, 54 galls formed, of which 37, or 68.52 per cent, reached maturity and none were destroyed by parasites. There was no loss due to overcrowding of galls in either year. Thus the presence of parasites in 1932 was sufficient to cause a reduced infestation in 1933, but the absence of parasites in 1933 allowed such a high percentage of galls to reach maturity that a greatly increased infestation is indicated for 1934. In the field in 1932, 8.68 per cent of 1,588 galls in one orchard and 9.14 per cent of 5,927 galls in another orchard reached maturity. Parasites were abundant in both orchards and were largely responsible for the low rate of maturity. In the field in 1933, 8.92 per cent of 482 galls in an orchard in which parasites were abundant and 19.42 per cent of 515 galls in an orchard in which parasites were only moderately abundant reached maturity.

A number of contact insecticides, alone and in combination, have been tested for their efficiency in controlling infestations of *P. devastatrix* when applied late in the dormant period and during the delayed-dormant period. The materials used, the strengths at which they were used, the time that they were applied, and the results effected by them are presented in Tables 1 and 2.

All applications were made with power sprayers to orchard infested trees, 4 or 5 trees being used for each test. The results were checked at the end of the period of gall development, the total number of galls on 200 twigs per block in 1932 and on 50 twigs per tree in 1933 being taken as a representative sample. Count twigs were selected at random, some from each side of each tree in all blocks, those in the check blocks being selected and tagged at the beginning of the period of gall

TABLE 1. RESULTS OF EXPERIMENTS WITH SPRAYS FOR THE CONTROL OF *Phylloxera devastatrix* ON PECANS IN TWO ORCHARDS IN LOUISIANA, SEASON OF 1932

Materials used	Period when applied	On Stuart, at New Iberia, La.		On Schley, at Whiteville, La.	
		Average galls per twig[1]	Reduction of infestation	Average galls per twig	Reduction of infestation
		Number	Per cent	Number	Per cent
Lubricating-oil emulsion (3 per cent)	Dormant	1.68	93.12	1.72	74.38
Liquid lime sulphur 12.5 gallons, plus water to make 100 gallons	Dormant	——	——	.62	90.77
Liquid lime sulphur 12.5 gallons, plus nicotine sulphate (40 per cent nicotine) 1 pint, plus water to make 100 gallons	Dormant	.38	98.44	.18	97.39
Lubricating-oil emulsion (3 per cent)	Delayed dormant	2.37	90.29	2.22	67.01
Nicotine sulphate 1 pint, plus potash fish-oil soap 4 pounds, plus water to make 100 gallons	Delayed dormant	1.36	94.44	.26	96.20
Lubricating-oil emulsion (3 per cent), plus 1 pint of nicotine sulphate per 100 gallons	Delayed dormant	.79	96.78	.29	95.68
Liquid lime-sulphur 2.5 gallons, plus nicotine sulphate 1 pint, plus water to make 100 gallons	Delayed dormant	.47	98.07	.38	94.34
Unsprayed check	——	24.36	——	6.71	——

[1] A twig (the unit of infestation) includes a shoot of the current season's growth and all leaves, leaf and leaflet stems, and nuts attached to it.

TABLE 2. RESULTS OF EXPERIMENTS WITH SPRAYS FOR THE CONTROL OF *Phylloxera devastatrix* ON PECANS IN TWO ORCHARDS IN LOUISIANA, SEASON OF 1933

Materials used	On Stuart, New Iberia, La.				On Schley, Whiteville, La.	
	Dormant		Delayed dormant		Delayed dormant	
	Average galls per twig	Reduction of infestation	Average galls per twig	Reduction of infestation	Average galls per twig	Reduction of infestation
	Number	Per cent	Number	Per cent	Number	Per cent
Liquid lime-sulphur 12.5 gallons, plus water to make 100 gallons	0.015	99.06	——	——	0.080	96.67
Liquid lime-sulphur 12.5 gallons, plus nicotine sulphate (40 per cent nicotine) 1 pint, plus water to make 100 gallons	.000	100.00	——	——	.016	99.33
Liquid lime-sulphur 2.5 gallons, plus water to make 100 gallons	——	——	0.035	97.80	——	——
Liquid lime-sulphur 2.5 gallons, plus nicotine sulphate 1 pint, plus water to make 100 gallons	.010	99.37	.005	99.69	.120	95.00
Liquid lime-sulphur 2.5 gallons, plus nicotine sulphate ½ pint, plus water to make 100 gallons	——	——	.100	93.71	——	——
Bordeaux mixture (3–4–50)	——	——	——	——	2.332	2.83
Unsprayed check (Schley group 1)	——	——	——	——	2.400	——
Bordeaux mixture (3–4–50), plus 1 pint of nicotine sulphate per 100 gallons	——	——	——	——	.376	80.87
Bordeaux mixture (3–4–50), plus ½ pint of nicotine sulphate per 100 gallons	——	——	——	——	.600	69.47
Nicotine sulphate 1 pint, plus potash fish-oil soap 4 pounds, plus water to make 100 gallons	.025	98.43	.025	98.43	.224	88.60
Nicotine sulphate ½ pint, plus potash fish-oil soap 4 pounds, plus water to make 100 gallons	.240	84.91	.070	95.60	.772	60.71
Unsprayed check (Schley group 2)	——	——	——	——	1.965	——
Lubricating-oil emulsion (4 per cent), plus 1 pint of nicotine sulphate per 100 gallons	.120	92.45	——	——	.160	78.52
Lubricating-oil emulsion (3 per cent), plus 1 pint of nicotine sulphate per 100 gallons	.010	99.37	.025	98.43	.064	91.41
Lubricating-oil emulsion (3 per cent), plus ½ pint of nicotine sulphate per 100 gallons	.035	97.80	.355	77.67	.084	88.72
Unsprayed check (Schley group 3)	——	——	——	——	.745	——
Unsprayed check (Stuart blocks)	1.590	——	1.590	——	——	——
Summer oil emulsion (2 per cent), plus 1 pint of nicotine sulphate per 100 gallons. Applied May 28, 1932	.995	37.42				

development while those in the sprayed blocks were selected as they were examined at the time of the final check. In instances where it was necessary to make counts on additional check trees because of an uneven distribution of the infestation over the experimental orchard, the twigs were selected at random at the time of the final check, as on sprayed trees.

In 1932 the Stuart block located in an orchard near New Iberia was heavily infested, while the Schley block located in an orchard at Whiteville was lightly infested. In 1933 both orchards were very lightly infested. The experimental results obtained were very promising, whether the infestation was light or heavy, as an examination of Tables 1 and 2 will indicate.

Commercial nicotine sulphate (40 per cent nicotine), 1 pint in 100 gallons of spray, in combination with either potash fish-oil soap or liquid lime-sulphur, was superior to all other materials or combinations of materials tested, giving consistently good results in every test. Nicotine sulphate was about equally effective with the summer and dormant-season strengths of liquid lime-sulphur. Liquid lime-sulphur by itself, either summer or dormant-season strength, gave inconsistent results, proving very effective in some cases and only moderately so in others. A combination of nicotine sulphate (40 per cent nicotine), 1 pint in 100 gallons, with lubricating-oil emulsion was approximately as effective as the same strength of nicotine with soap or with lime-sulphur. Used with a weak lubricating-oil emulsion, the nicotine proved as satisfactory as with one of dormant-season strength. Lubricating-oil emulsion, dormant-season strength, was not so effective as some other materials tested, although it did give a considerable degree of control. A combination of nicotine sulphate and Bordeaux mixture was less effective than the other nicotine combinations tested, while Bordeaux mixture by itself gave no control, as was to be expected. A reduction of the nicotine dosage from a dilution of 1–800 to 1–1,600 resulted in a marked reduction in effectiveness. The results obtained by late-dormant and delayed-dormant applications were about equally satisfactory, the chief concern apparently being to make a thorough application of an effective material before the galls form. A spray containing nicotine sulphate 1–800 in combination with a 2 per cent summer-oil emulsion, applied late in May 1932 during the period of gall opening, egg deposition, and hatching of the early summer forms, failed to give an effective degree of control.

As a result of the tests reported upon above, the application of a spray either late in the dormant period or during the delayed-dormant period, according to convenience, using nicotine sulphate 1–800 (1 pint to 100 gallons of spray) in combination with either potash fish-oil soap at the rate of 4 pounds to 100 gallons of spray or liquid lime-sulphur (testing at least 32° Baumé) at the rate of 2½ gallons to 100 gallons of spray, is recommended for effecting control of *P. devastatrix* on pecans. If the phylloxera infestation is light, the thorough application of a spray containing either liquid lime-sulphur at the rate of 2½ gallons to 100 gallons of spray or nicotine sulphate 1–800 in combination with a one half of 1 per cent lubricating-oil emulsion should give a satisfactory degree of control. In those orchards in which it is necessary to spray to control the obscure scale (*Chrysomphalus obscurus* Comst.) as well as phylloxera, a single application, late in the dormant period, of a spray containing nicotine sulphate 1–800 in combination with a 4 or 5 per cent lubricating-oil emulsion is recommended.

INSECTS OBSERVED ATTACKING CROTALARIA IN LOUISIANA IN 1932 AND 1933

By W. A. DOUGLAS, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

In recent years several species of *Crotalaria* have been gaining favor as a leguminous crop and promise, to some extent, to take the place of soybeans in Louisiana. During 1932 and 1933 the writer made observations on the insects which attacked *Crotalaria* in southern Louisiana. These notes give such information on the subject as is available at present.

Three species of insects observed to attack *Crotalaria* are of considerable importance. These are the green stink bug (*Nezara viridula* L.), the beautiful tiger moth (*Utetheisa bella* L.), and the striped blister beetle (*Epicauta lemniscata* Fab.)

The green stink bug attacks the seed pods and hinders the development of seed. As many as 22 bugs have been found on an ordinary-sized plant of *Crotalaria spectabilis*. The nymphs, as well as the adults, attack the seed pods. This bug is difficult to control. It is heavily parasitized late in the season by the tachinid fly, *Trichopoda pennipes* Fab.

Utetheisa bella was first observed attacking *Crotalaria* in this section in 1933. It was first noted at Franklin, La., in May. The larvae, which are covered with hairs ⅛ to ¼ inch long, attack the young plants and eat the leaves. About 25 per cent of the plants in a field of *Crotalaria* at Franklin were injured in 1933. When the larvae are ready to pupate they spin a very light sort of web which is attached to the leaves. In some cases the leaves are slightly rolled and the bright brown pupae are attached within the roll. These caterpillars were reported on *Crotalaria* in the July 1933 Insect Pest Survey Bulletin, by J. M. Robinson in Alabama and by J. W. Ingram in Georgia. An experiment on control was carried on at Franklin in 1933, in which sodium fluosilicate, barium fluosilicate, calcium arsenate, and lead arsenate were applied on the infested plants. All of these dusts gave fair control. Lead arsenate applied as a dust at the rate of 6 pounds per acre to plants about 16 inches high gave the best results. No burning of foliage resulted from the use of any of these materials.

The striped blister beetle attacked *Crotalaria intermedia* growing at the Rice Experiment Station at Crowley, La., in 1933. This beetle completely defoliated *Crotalaria intermedia* and did not touch *Crotalaria spectabilis* which was growing on the next row in the same plot. The beetles skipped over the *Crotalaria spectabilis* and started feeding on Biloxi soybeans. The photograph shows, on the right, the extent of injury to *Crotalaria intermedia*. *C. spectabilis* is shown in the center, and Biloxi soybeans, on which slight feeding had occurred, on the left.

Other insects, such as leaf-eating beetles, leafhoppers, and grasshoppers, have been found on *Crotalaria*, but they have been of minor importance.

Fields of *Crotalaria* should be watched closely for signs of injury by chewing insects and lead arsenate applied as a dust as soon as the injury begins to show. This treatment controlled all leaf-eating species and did not burn the foliage. The rate of application should be varied, according to the size of plants, to give good coverage.

FIG. 102.—Work of blister beetle, *Epicauta lemniscata*: Right, *Crotalaria intermedia* completely defoliated; center *C. speciabilis* untouched; left, Biloxi soybeans showing slight feeding.

THE ROLE OF PREDATORY AGENTS IN THE ARTIFICIAL CONTROL OF THE MOUNTAIN PINE BEETLE

By HENRY J. RUST, *Senior Scientific Aide, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Coeur d'Alene, Idaho*

Since 1906 the removal of bark from infested trees has been a standard method of bark-beetle control[1] for those species that develop between the bark and the wood. The effectiveness of this method has remained unquestioned until recently, when it was found that under certain conditions the exposed brood of the mountain pine beetle (*Dendroctonus monticolae* Hopk.) could transform to the adult stage and attack healthy trees. Because of the reliance placed on the peeling method, this discovery necessitated an immediate study to ascertain (1) under what conditions the exposed brood could reach maturity, and (2) what factors cause the mortality of exposed brood.

The study was made in the following localities in order that as wide a variety of conditions as possible might be represented: (1) Lodgepole pine stand in the Bitterroot National Forest, Montana, 1928; (2) western white pine stand in the Coeur d'Alene National Forest, Idaho, 1929; (3) western white pine stand in the Clearwater National Forest, Idaho, 1930; (4) western white pine stand in the Kaniksu National Forest, Washington, 1930.

EFFECT OF PROTECTION ON EXPOSED BROODS.—Two types of cages were used to determine whether or not the exposed broods of the mountain pine beetle could reach maturity in the duff if protected from all predators. The first type consisted of a light wooden frame 6 feet long, 2 feet wide, and 1 foot deep, covered with 18-mesh wire cloth and divided into three compartments, one for larvae, one for pupae, and one for new adults. The cages were set in the soil so that the wire bottom was buried to a depth of 3 inches. The soil and litter removed in setting the cages were sifted and examined to remove predators, and then placed in the cages in as nearly normal position as possible. On the Coeur d'Alene Forest groups of three smaller cages, 2 feet square and 18 inches deep, were used instead of the more unwieldy larger ones. Mountain pine beetles in various stages were placed in the different compartments and cages, and were supplied with fresh logs for attack in the event that any of the insects matured.

This type of cage was not entirely satisfactory, however, because small ants were able to enter and destroy some of the brood. Also, the construction of the cage hindered proper ventilation, and this resulted in a moldy growth within the cage. Hence, another type of cage was developed to overcome these difficulties. It was constructed of wire screen in the form of a cone around the basal 4 feet of a healthy lodgepole pine tree, with a wire-screen floor which was fastened to the tree and to the outer edge of the cage. In order to exclude ants, large quantities of sticky tree-banding material were applied on all seams and the cage was surrounded with a trench filled with old crank-case oil.

[1]Hopkins, A. D. 1909. Practical information on the scolytid beetles of North American forests. I. Barkbeetles of the genus Dendroctonus. U. S. Dept. Agr. Bur. Ent. Bull. 83 (pt. 1), 169 pp., illus.

Although it was possible completely to exclude ants from only cage 2, nevertheless, the data in Table 1 show that with only partial protection the prepupal larvae, pupae, and new adults of the mountain pine beetle can mature in the duff.

TABLE 1. DEVELOPMENT OF EXPOSED BROODS OF THE MOUNTAIN PINE BEETLE WITHIN THE CAGES

Timber	Type of cage	Cage no.	Brood stage	Individuals placed in in cage	Attacks in green material
				Number	*Number*
Lodgepole pine	Compartment	1	Larval	120	0
	Compartment	1	Pupal	175	4
	Compartment	1	New adult	130	27
	Cone	2	Larval	50	18
	Cone	3	Pupal	100	42
Western white pine	Individual square	12	New adult	300	26

EFFECT OF PREDATORY AGENTS ON EXPOSED BROODS.—The experiments described above show clearly that fully fed brood of *Dendroctonus monticolae* that has been exposed by barking is able to complete transformation and attack fresh trees. However, the work of ants in the cages indicated that factors other than physical must be taken into consideration. Therefore, 46 open survival plots were established in order that the effect of predatory agents upon unprotected brood exposed by peeling might be measured. The plots were distributed in the Bitterroot, Coeur d'Alene, and Kaniksu National Forests at elevations ranging from 2,500 to 5,400 feet, and represented different exposures and varying types of ground cover.

Some of the plots were under constant observation during the day from the time that brood was placed in them until all the insects had been destroyed. On the remaining plots only one examination was made. These plot studies were supplemented by observations through out the areas where control operations were being conducted.

TABLE 2. SURVIVAL OF EXPOSED BROODS OF THE MOUNTAIN PINE BEETLE UNDER VARIOUS CONDITIONS

Exposure[1] and ground cover	Brood stage[2]	Plots	Size of plots	Individuals per plot	Length of exposure	Brood destroyed	Agencies responsible for destruction
		Number	*Feet*	*Number*	*Days*	*Per cent*	
Bitterroot National Forest (lodgepole pine)							
S, dry litter	L, P, NA	25	1 by 1	81	4	100	Ants
Do	L, P, NA	1	1 by 10	1,000	5	99	Do.
N, dry moss	L, P, NA	8	1 by 1	81	6	100	Centipedes
Coeur d'Alene National Forest (white pine)							
S, moist deep duff	L	2	1 by 22	5,000	7	100	Mammals, ants
S, E, W, moist deep duff under peeled logs	L, P	3	1 by 22	5,000	8	100	Do.
S, moist deep duff 20 feet from peeled log	L, P	1	1 by 22	5,000	8	100	Do.
S, moist deep duff 50 feet from peeled log	L, P	1	1 by 22	5,000	10	100	Do.
S, moist deep duff 450 feet from peeled log	L, P	1	1 by 22	500	10	100	Do.
Kaniksu National Forest (white pine)							
Flat, duff	NA	2	4 by 5	400	8	56	Ants
Flat, moist duff	L	1	4 by 5	1,000	8	94	Mammals, ants
Flat, duff	L, P	1	4 by 5	800	2	99	Ants

[1] S, south; N, north; E, east; W, west.
[2] L, larvae; P, pupae; NA, new adults.

The data from the survival plots are summarized according to forests in Table 2.

The data in Table 2 indicate that: (1) after exposures of from 2 to 10 days, ants, centipedes, and small mammals destroy the brood of the mountain pine beetle; (2) ants are the most valuable predatory agents causing this destruction in the lodgepole-pine type where the exposures are sunny and the duff rests on sandy soils; (3) in the white-pine type small mammals also are valuable predatory agents; (4) ants assist the mammals in the white-pine type; (5) on northern exposures where moss is the primary soil covering, the exposed brood is destroyed by centipedes; (6) new adult beetles seem to have the best chance of surviving the exposure, and are not always destroyed by predators.

PREDATORS DESTROYING THE EXPOSED BROOD OF THE MOUNTAIN PINE BEETLE.—Ants of the following species were found to destroy the exposed broods of the mountain pine beetle:

Bitterroot National Forest

Formica rufa aggerans Wheeler
Formica fusca var. *subaenescens* Emery
Formica fusca var.
Leptothorax sp.
Tapinoma sessile Say
Lasius niger var. *americanus* Emery

Coeur d'Alene National Forest

Lasius niger var. *americanus* Emery

Clearwater National Forest

Lasius niger var. *americanus* Emery

Kaniksu National Forest

Lasius niger var. *americanus* Emery

The following small mammals were trapped on the areas and are listed in order of their abundance:

Coeur d'Alene National Forest

White-footed mouse (*Peromyscus maniculatus artemisiae* Rhoads) (Fig. 103)
Vole (*Microtus mordax mordax* Merriam)
Shrew (*Sorex cinereus cinereus* Kerr)
Chipmunk (*Eutamias ruficaudus simulans* Howell)
Rocky Mountain jumping mouse (*Zapus princeps princeps* Allen)

Clearwater National Forest

Shrew (*Sorex cinereus cinereus* Kerr)
Vole (*Clethrionomys gapperi saturatus* Rhoads)
White-footed mouse (*Peromyscus maniculatus artemisiae* Rhoads)
Chipmunk (*Eutamias ruficaudus simulans* Howell)

Kaniksu National Forest

White-footed mouse (*Peromyscus maniculatus artemisiae* Rhoads)
Chipmunk (*Eutamias ruficaudus simulans* Howell)
Shrew (*Sorex obscurus obscurus* Merriam)

CONCLUSIONS.—As a result of this study it was found that, if thoroughly protected from all predators, a large percentage of prepupal larvae, pupae, and immature adults of the mountain pine beetle will

FIG. 103.—Adult white-footed mouse (*Peromyscus maniculatus artemisiae*) feeding on larvae and pupae of the mountain pine beetle.

mature in the duff and successfully attack healthy standing trees. It was also found that few of the exposed immature broods within the duff either on the plots or around freshly peeled infested trees remained undiscovered by predators after 10 days. It is therefore concluded that, on areas where ants, centipedes, and small mammals, such as those mentioned in the paper, are present, the peeling method of control can be conducted with success while the beetles are in the larval and pupal stages. Furthermore, it can be rather safely assumed that in all white-pine and lodgepole-pine stands a sufficient number of these beneficial species are present to make the peeling method of control successful.

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POSSIBLE EFFECT OF REGULATED PRODUCTION ON INSECT DAMAGE TO CORN[1]

By J. H. Bigger, *Illinois National History Survey*

It is of immediate economic importance to farmers to consider the effect on the insect population and extent of crop losses due to insects under revised cropping schedules which are resulting from efforts of various agencies to manage crop production in the great corn belt area. The Illinois entomologists believe that they have data which indicate what the results of any logical program will be.

It is considered most likely that the reduction of corn and wheat acreages will lead to increases in the acreage of legumes. This trend has, in fact, already started and statements of intention show that it will proceed further during the spring of 1935.

History of Project.—During 1929 a project was started by the author in cooperation with Dr. F. C. Bauer, in charge of soils experiment fields of the Illinois Agricultural Experiment Station, which had as its object a determination of the abundance of root infesting insects on corn grown in various rotations.

Because of its timely nature a portion of the results are brought out in this paper. Data are available covering periods of 2–6 years on 5 rotations or tillage practices. The percentage of hills found infested by one or more of the principle corn root infesting insects is used as an index. The examination is made after the first and before the second cultivation, when the corn is 6–8 inches tall. Two samples of 100 hills each are dug and the roots and surrounding soil carefully examined for the presence of any such insects. The figures to be quoted are the average of the 2 examinations.

The records show the combined infestation by White Grubs, *Phyllophaga;* Wireworms, *Elateridae;* Corn Root Aphids, *Anuraphis maidiradicis* Forbes; Grape Colaspis, *Colaspis brunnea* Fab.; and the Seed Corn Maggot, *Hylemyia cilicrura* Rond.

Project at the Carthage Field.—On the Illinois experiment fields rotations studies are divided into 2 groups. There is a so-called 'major series' which carries a rotation such as is adapted to the soil and climatic conditions of the particular part of the state in which the field is located. This is usually a 4-year rotation. There is also a supplementary rotation which may be recommended as a substitute under conditions where the major rotation is not adapted to any certain farm. This is known as the 'minor series.'

The longest series of consecutive examinations have been made at the field at Carthage, in Hancock county, western Illinois. The major series at this field consists of a rotation of corn, oats, red clover, wheat. The series is divided into (1) a crop residue manure system where the corn stalks and the fall crop of red clover are plowed under and sweet clover is grown in the wheat as a green manure crop, and (2) an animal

[1]Contribution to Project 3.9 of the Illinois Natural History Survey. (Revised December, 1934.)

manure system where corn crop residues are removed and manure equal to the total weight of the crop produced during the previous rotation is plowed under for corn. In this group one crop of red clover is harvested and the second crop plowed under previous to wheat seeding. This program with slight changes has been followed since 1912. The soil is about equally divided between black silty clay loam on clay (Grundy silty clay loam), and grayish brown silt loam on tight clay (Grundy silt loam, grayish phase). The land is plowed for corn as soon as the sweet clover has started growth in the spring. Planting is done as early in May as conditions permit, and has varied from May 5 to June 1. Examinations have varied from May 27 to June 21.

Table 1 shows the infestation on the major series at Carthage during the period 1929–1934.

TABLE 1. TOTAL PER CENT INFESTED HILLS. MAJOR SERIES, CARTHAGE, ILL., 1929–1934

	1929	1930	1931	1932	1933	1934	Average
Animal residue	30.5	10.5	59.0	49.0	29.5	15.0	32.2
Crop residue	40.0	7.0	60.0	29.5	23.0	10.0	26.6

A minor rotation has also been maintained on this field. From 1920 to 1930 this rotation was corn, corn, oats. Sweet clover was grown in the oats and plowed under for corn the following year. Table 2 gives the records for 1929 and 1930.

TABLE 2. TOTAL PER CENT INFESTED HILLS. MINOR SERIES, CARTHAGE, ILL., 1929 AND 1930

	1929	1930	Average
First year corn	58.0	41.5	49.8
Second year corn	62.5	90.5	76.5

In 1930, due to severe losses in this rotation caused by rootworm damage the rotation was changed to corn, oats, wheat. (Table 2 reflects abundance of corn root aphid and other insects rather than rootworm.) Sweet clover is grown in the wheat and plowed under for corn the following spring. Table 3 shows the records obtained to date in this rotation on the same plots. The plot checked in 1932 and later has been subjected to this change of rotation in full.

TABLE 3. TOTAL PER CENT INFESTED HILLS. MINOR SERIES, CARTHAGE, ILL., 1931–1934

	1931	1932	1933	1934	Average
First year corn	42.0	45.8	19.5	10.5	29.5

Discussion of Carthage field results.

Records of the major series in Table 1 clearly indicate that such a rotation produces a crop relatively low in insect infestation especially when the list of insects is taken into consideration. This rotation accomplishes the aim of agronomists, who for years have advocated a 25% legume acreage on farms of the state. Especially does the freedom from corn pests show when a comparison with the minor (poor) rotation, as shown in Table 2, is made. The high figures in Table 1 of 59.9% and 60.0% shown in 1931 are due to a very heavy infestation of the corn root aphid during the early part of the season.

Table 2 shows what will happen when a rotation in which corn is grown too frequently on the soil is used. These results are largely due

to corn root aphids. It has been shown elsewhere[2, 3, 4] that a continuation of cropping to corn more than 2 years also increases the incidence of the corn rootworm. The fact that this condition is due to the rotation is clearly shown in Table 3 when we see that a reduction of the amount of corn in the rotation has apparently cleared these plots of heavy infestations despite the fact that the major rotation carried heavier infestations in both 1931 and 1932 than it did in 1930.

PROJECT AT THE CLAYTON FIELD.—Records are available for the field at Clayton, in Adams county, western Illinois, covering a 4-year period. Necessary retrenchment and a change in conditions on the field caused this to be at least temporarily discontinued in 1933. The rotation is corn, oats, red clover, wheat. The crop residue and animal residue systems are the same as at Carthage. The soil is brown silt loam on clay (Grundy silt loam). An added feature was that 2 dates of plowing were used, thus dividing the field into 4 sections for the purpose of this project. Early plowing was done as soon as sweet clover had started growth in the spring, and late plowing was done 2–3 weeks later. The entire field was then disced and prepared for corn seeding. Plowing dates were: 1929—April 19 and May 9; 1930—April 8 and April 23; 1931—April 15 and May 1; 1932—April 13 and April 27. The data obtained are shown in Table 4.

TABLE 4. TOTAL PER CENT INFESTED HILLS. MAJOR SERIES, CLAYTON, ILL., 1929–1932

	1929	1930	1931	1932	Average
Early plow					
Animal residue	53.3	42.5	—[1]	49.5	48.4
Crop residue	47.2	25.0	15.0	45.5	33.2
Late plow					
Animal residue	38.1	34.5	22.0	30.0	31.2
Crop residue	32.5	27.5	22.0	28.4	27.6

[1]No plot here in 1931.

Discussion of Clayton field results.

The records of the Clayton field again demonstrate that a low per cent of infestation may be expected where a properly executed rotation with sufficient legume acreage is followed. Again the high infestations of 1929 and 1932 were obtained when root aphids were abundant.

The late plowed area appears superior to the early plowed solely because of more effective root aphid control and is a special condition to be reported at some other time.

PROJECT AT THE HARTSBURG FIELD.—Examinations were started during 1931 on the field at Hartsburg in Logan county, central Illinois. This field has been in operation since 1923 with a 4-year rotation of corn, corn, oats, wheat. Hubam clover is grown in the oats and plowed under for wheat. Otherwise the field is handled the same as the Carthage field. The soil is black clay loam (Grundy clay loam). The data are shown in Table 5.

[2]Bigger, J. H., A Year's Progress in Solving Farm Problems in Illinois, 1930–31 pp. 139–140.

[3]Bigger, J. H., A Year's Progress in Solving Farm Problems in Illinois, 1931–32, pp. 177–179.

[4]Bigger, J. H., Short Rotation Fails to Prevent Attack of *D. longicornis* Say. J. Ec. Ent. 25, 2, Apr. 1932.

TABLE 5. TOTAL PER CENT INFESTED HILLS. MAJOR SERIES, HARTSBURG, ILL. 1931–1933

	1931	1932	1933	1934	Average
First year corn					
Animal residue	37.3	24.2	17.5	25.5	26.1
Crop residue	39.5	25.5	22.0	19.0	26.5
Second year corn					
Animal residue	45.5	48.8	18.2	52.5	41.3
Crop residue	58.0	68.0	17.5	49.0	48.1

Discussion of the Hartsburg field results.

At the Hartsburg field we have a direct comparison of resulting conditions where 2 years of corn in succession are followed. It is shown that the second year of corn is inferior to the first year. It is not claimed that this rotation is economically unsound. Under the soil conditions existing at Hartsburg this rotation produces well. But if the corn were continued another year and the rate of increase of infestation continued economic damage would undoubtedly occur. These records do unquestionably demonstrate that the minimum amount of corn compatable with good practise produces a crop freer from insect injury.

GENERAL DISCUSSION.—Reduction of the acreages of corn and wheat during 1934 and 1935 will undoubtedly lead to the introduction of a higher per cent of crop land in legumes. Rotation changes which are bound to occur will include a shorter succession of corn, and more of this will follow after legumes than in the past. These changes will produce conditions approaching the much desired 25% of land in legumes. When this condition is reached on the majority of farms a situation similar to that on the Illinois experiment fields will be found. Low infestation by the root feeding insects will result. Insect losses will be reduced to a minimum. Under such conditions white grubs and wireworms will not be an important factor in production. Losses by root aphids will be scant. Proper handling will free the crop from Colaspis and seed maggot damage. The farmer will be able to regulate his production and be comparatively free from the necessity for over-planting to allow for insect losses in producing any desired amount of crop.

These conclusions are substantiated by the history of more than 30 soils experiment fields in Illinois where damage that would be affected by the rotations practiced is not a factor in production. Other more detailed conclusions suggest themselves, but they will not be discussed here.

We believe that a regulated cropping system which will decrease the per cent of corn and increase the per cent of legumes in the rotation will result in a high relative freedom from the attack of many important insects attacking the root and young plantlet of corn.

TWO HEMIPTERA FOR USE AS EXPERIMENTAL INSECTS IN INSECTICIDE STUDIES

By W. A. SIMANTON and FLOYD ANDRE,[1] *Iowa State College*

There are very few species in the order Hemiptera which can be reared successfully in the laboratory throughout the year. Entomolo-

[1]Co-authorship.

gists conducting laboratory experiments in insect physiology and toxicology are often limited in their work with Hemiptera by the unavailability of a large number of individuals of a given species during the winter months.

Two species, *Lygaeus kalmii* Stål, and *Oncopeltes fasciatus* (Dallas), both members of the hemipterous family Lygaeidae, have been reared successfully in large numbers throughout the year, by the writers, under laboratory and greenhouse conditions.

Lygaeus kalmii occurs in abundance over most of the United States and has as its principal host milkweeds of the genus *Asclepias*. Adults may be collected in numbers from the milkweed plants in the late summer and autumn. In the laboratory the insects are placed in glass and cheesecloth cages, each furnished with a vial of water in which is inserted a cellucotton wick. A small ball of cotton is placed in each cage to serve as a medium for oviposition. Milkweed seeds introduced into the cages, with or without the pods, serve as the sole supply of food. The bugs will live and breed on the dry seeds and pods of the milkweed. By caging the pairs separately and placing them at 30° C. (the optimum temperature for development) and about 73% relative humidity (saturated NaCl), great numbers of eggs may be obtained within a few days. The yellowish eggs are usually laid in masses deep in the cotton. There are five instars each lasting from three to eight days depending upon environmental conditions. The adults, which are red and black, measure 12–14 mm. in length. The membrane is always margined with white and it may or may not bear two white spots. Since the females lay an average of very close to 1,100 eggs, many hundreds of individuals may be reared within a few weeks' time. The mortality of this species is low, especially if the stock is moved to clean cages every few weeks. By removing the egg masses from the cotton and allowing all eggs of the same age to hatch in a separate cage the mortality is nearly eliminated. A generation may be obtained every thirty days.

Oncopeltes fasciatus occurs in moderate abundance over the southern half of the United States. Although it does not, so far as is known, over-winter north of 40° latitude, it may often be taken in the northern states from milkweed during the late summer and early fall. It is reared in the laboratory in the same manner as *Lygaeus kalmii*, but requires more careful attention. The adults, which are black and bright red, measure 14–17 mm. in length. The females will often lay over 200 eggs. Maximum results are obtained when the cages are cleaned at short intervals and when not more than thirty individuals are placed together in the same cage. It is particularly important with *O. fasciatus* that the eggs of the same age be hatched separately.

Preliminary toxicological studies with these two species indicate that *L. kalmii* is quite resistant to several common contact poisons; however, the larger species, *O. fasciatus*, appears to have much less resistance to the same insecticides.

Two papers, by the writers, concerning the biology of these two species are now in press.

THE RESISTANCE OF LEAVES OF SOME PUBESCENT RED CLOVERS TO PUNCTURING[1]

By H. H. JEWETT, *Kentucky Agricultural Experiment Station*

Tests made on leaves of a Kentucky red clover and an Italian red clover showed that the leaves of the Kentucky clover were more resistant to puncturing than those of the Italian clover.[2] The Kentucky clover, also, has been found to be more resistant than the Italian clover to injury by the leafhopper, *Empoasca fabae*.

Tests for comparing the resistance of leaves of other red clovers to puncturing were made during the season of 1933. The clovers used were hairy or pubescent clovers and were a part of a number used in other resistance tests. The clovers were Kentucky 101, Wisconsin 4, Oregon 6 and Oregon 8.

METHOD OF PROCEDURE.—The clovers were grown in pots in the greenhouse. They were the same age and were grown under the same conditions of soil, moisture, lighting and temperature. The plants used were graded as nearly as possible as to size and condition of growth.

The punctures were made in the central portion of each leaf by a fine needle attached to a carefully made instrument.[2] The weights necessary to force the needle through the leaves varied considerably and 503 leaves of each of the four clovers were punctured.

Results. The weights, in grams, necessary to force the needle through the leaves all came within the range of .275 to 2.19. The weights for each clover were arranged in a table and the mean and standard deviation were determined for each. The standard error of the difference of the means of any two clovers could then be determined. The actual difference between these two means was then divided by the standard error of the difference of the two means. The data for the tests are summarized in Table 1.

TABLE 1. SUMMARY OF DATA ON PUNCTURING TESTS

A

Clover	Mean	Standard deviation
Ky. 101	1.3641	.3561
Wisc. 4	1.2512	.3378
Oreg. 6	1.2682	.3169
Oreg. 8	1.2175	.3763

B

True difference between means	Standard error of the difference of the means	No. of times the true difference exceeds standard error
Ky.—Wisc. = .1129	Ky., Wisc. = .0219	5.15
Ky.—Oreg. 6 = .0959	Ky., Oreg. 6 = .0212	4.52
Ky.—Oreg. 8 = .1466	Ky., Oreg. 8 = .023	6.37
Oreg. 6—Oreg. 8 = .0507	Oreg. 6, Oreg. 8 = .0219	2.30
Oreg. 6—Wisc. = .017	Oreg. 6, Wisc. = .0206	0.82
Wisc.—Oreg. 8 = .0337	Wisc., Oreg. 8 = .0225	1.49

DISCUSSION.—It is customary to take a difference of three times the standard error as indication of complete reliability, since -3σ includes practically all of the cases in the distribution of the difference below

[1]The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

[2]Journal of Economic Entomology, V. 26, Dec., 1933. The Resistance of Leaves of Red Clover to Puncturing.

the mean. In the tests reported here we find that the true difference between the means is 5.15 times the standard error of the difference of the means in case of the Kentucky clover and Wisconsin clover, 4.52 times the standard error in case of the Kentucky clover and Oregon 6 clover, and 6.37 times the standard error in case of the Kentucky clover and Oregon 8 clover. We may be certain, therefore, that there is a true difference between the average weights in favor of the Kentucky clover and that the average Kentucky leaf is more difficult to puncture than the average Wisconsin 4, Oregon 6 and Oregon 8 leaves.

The true difference between the means is 2.3 times the standard error, in case of the Oregon 6 clover and Oregon 8 clover, .82 times the standard error, in case of the Oregon 6 clover and Wisconsin clover, and 1.49 times the standard error in case of the Wisconsin clover and Oregon 8 clover. Under the Normal Probability Curve (P 91, Table 10, Statistics in Psychology and Education, by Garrett), we find that 9786 cases in 10,000 fall within the limits set by -2.3σ and $+2.3\sigma$; 5878 cases in 10,000 fall within the limits set by $-.82\sigma$ and $+.82\sigma$; and and 8637 cases in 10,000 fall within the limits set by -1.49σ and $+1.49\sigma$. The chances are, therefore, 9786 in 10,000 that the true difference between the averages of the Oregon 6 and Oregon 8 weights is greater than zero; 5878 in 10,000 that the true difference between the averages of the Oregon 6 and Wisconsin weights is greater than zero; and 8637 in 10,000 that the true difference between the averages of the Wisconsin and Oregon 8 weights is greater than zero.

Tests made in 1931 show that the Kentucky clover is more resistant to hopper injury than the Oregon and Wisconsin clovers and that Oregon 6 clover is more resistant than either the Oregon 8 and Wisconsin clovers. The Wisconsin 4 clover in these tests was slightly less resistant than the Oregon 8 clover.[3]

THE COST OF CONTROLLING APPLE INSECTS AND DISEASES, WITH SPECIAL REFERENCE TO THE CODLING MOTH[1]

By M. S. Troth, *Orleans, Indiana* and G. Edw. Marshall, *Purdue University Agricultural Experiment Station*

The cost of the insecticides and fungicides and the labor involved in their application, is usually the basis for figuring the costs of producing insect and disease-free apples. However, there are such a multiplicity of items which must be considered in arriving at accurate cost figures and there is such a variation in operations from year to year that it is necessary to keep daily detailed data, and over a period of years if the figures are to be complete and reliable.

[3]Kentucky Agricultural Experiment Station, Bul. 329. The Resistance of Certain Red Clovers and Alfalfas to Leafhopper Injury.

[1]Contribution from the Department of Entomology, Purdue University Agricultural Experiment Station.

The figures and discussion here given are based on the operation of a 200-acre apple orchard in southern Indiana, which has an average annual production of 57,000 bushels. The records cover a period of eight years, 1926–1933, inclusive, during which time every item of labor and material and the receipts for every bushel of apples were carefully recorded. During this period the country has passed from high to very low prices and to partial recovery. Two of the years have been very favorable to scab and other apple diseases and at least four have been almost optimum for codling moth. Three years of the period were severe drouth years and three were excessively wet. With the variation in weather and marketing conditions the data herewith presented should be representative.

The figures in the following table are based on the total crop graded and packed, and represent a greater than average infestation of codling moth and a much lighter than average infestation of other insects and diseases.

TABLE 1. INSECT AND DISEASE CONTROL COSTS AS COMPARED TO TOTAL COST

Item	Total cost per bushel	Chargeable to insect and disease control	Chargeable to codling moth
Spray material	12.4	12.4	10.54
Spray labor	4.3	4.3	3.12
Thinning	4.5	3.1	2.32
Worming trees	3.1	3.1	3.10
Supervision	3.3	2.4	1.80
Grading	2.8	1.8	1.62
Scraping trees	1.3	1.3	1.30
Banding	.9	.9	.90
Pruning	2.2	.9	.85
General supplies	.8	.6	.45
Gas and oil	.6	.5	.45
Light and power	.5	.4	.36
Bait traps and emergence cages	.3	.3	.30
Repairs	.5	.3	.25
Screening Packing shed	.2	.2	.20
Cultivation	.8	.2	.20
Depreciation of special equipment	8.3	5.4	4.59
Miscellaneous	2.2	1.5	1.12
	Cost A 49.00c	Cost B 39.60c	Cost C 33.47c
All other costs	28.75c		
Total costs	77.75c	39.60c	33.47c

Since every orchard presents a different problem in location, weather conditions, control program, insect infestation, fertility, water supply, packing house equipment, efficiency, and a multiplicity of other details, the above figures should be understood to apply to one orchard only, but certainly for orchards in the same region and with a heavy codling moth infestation they should very closely approximate average conditions.

There might be some question as to why certain cost items in the table have been allotted as they have been. To forestall this, such items that might raise a question are mentioned. Thinning has been done to reduce the load on the tree, to break up clusters and thereby aid in codling moth control and, in some cases, to take off badly scabbed apples, but most of the thinning was done to remove wormy apples. As many as three trips were made over the orchard to take off first brood wormy apples, thus preventing maturity of these worms and consequently heavier second and third brood infestations.

Worming of the trees refers to detailed examinations of trees in winter to find all the overwintering larvae in cracks, crotches, split branches, bird nests, knot holes and around the base of the tree in the soil. The worms found are dug out and killed.

The charge of supervision is made on the growers' time and that of the foreman in the field and packing shed.

Grading is greatly complicated by scab and worms, and requires extra time and labor and increased vigilance in grading.

One third of the time is spent in hunting split branches and broken limbs that harbor codling moth when the pruning is done. The burning of the brush must be timely if emergence of moths is to be prevented.

General supplies cover the odd necessities used in the various operations in the orchard. Gasoline and oil is used mostly for sprayers and tractors.

Power is used as electrical current to pump spray water, to force it out to the field filling station, also as motive power in the grading and packing of the fruit, and lights are used in the packing house to operate electrocutor traps to destroy moths.

Repair bills are mostly on sprayers and graders and water pumping equipment.

The cost of the cultivation item is increased by two discings with extensions on the disc to get under the trees and thereby to turn up and destroy the codling moth in the pupal stage. Such treatment is most effective during a short period of about 10 days in the spring.

A charge is made on depreciation of special equipment such as sprayers, graders and power house equipment.

The total cost per bushel (77.75 cents) includes 28.75 cents which covers items not affected by insects and disease control, such as baskets, caps, liners, fertilizer, picking, packing, cover crops, and a few miscellaneous charges. Of this total, 50.9 per cent is chargeable to insects and disease, and 43.04 per cent to codling moth alone.

Since the *all other costs* figure of 28.75 cents is in no way affected by insects and disease control, it may be eliminated from discussion in the apportionment of percentages affecting insects and diseases. The first total shown in the column under total cost per bushel represents the total cost (Cost A 49.00 cents) of all items that may be affected by insects and disease control. The corresponding total shown in the second column (Cost B 39.60 cents) represents the part directly chargeable to insects and diseases, while that in the third column (Cost C 33.47 cents) represents the cost of codling moth control alone. The amounts directly chargeable to insect and disease control represents 80.9 per cent of the total cost, while the total codling moth control is 84.5 per cent of all insect and disease control costs. From these figures it is seen that 68.2 per cent of all costs relating to insect and disease control in the production of a bushel of apples is chargeable to codling moth control.

There has been no consideration made of interest on the investment or depreciation on the orchard development due to age. The trees on

the orchard development are valued at $33,000.00 and a 3 per cent annual depreciation set. This amounts to $1000.00 a year.

Certain other minor costs have not been mentioned because the relative unimportance of these was such that had one been mentioned many others would have to be included.

During this period no washing of the fruit has been done, therefore, no consideration of this operation has been given. In the future this must be included.

In conclusion it should be remembered that only fair commercial control of codling moth was obtained, notwithstanding the heavy monetary outlay, resulting from extreme orchard sanitation and heavy spray programs. Under heavy or increasing infestations these methods must be continued. Most growers may be forced to adopt the same practices in three-brood areas unless the efficiency of present methods is improved upon.

A STATISTICAL METHOD OF DETERMINING THE EFFICIENCY OF BANDING FOR CODLING MOTH, WITH EIGHT YEARS' RESULTS

By R. E. Barrett

Bands for trapping hibernating codling moth larvae are extensively used as a supplementary control measure and a rather extended list of papers, particularly dealing with chemically treated bands, is accumulating in the literature. The efficiency of bands as a control measure has, however, largely been overlooked. To the writers knowledge, only a few investigators have published data on the efficiency of bands and in every case conclusions were drawn from a few trees. It therefore seems worth while to make available to workers the following information based on approximately 210,000 walnut trees covering a period of eight years.

Since 1926 individual tree records have been kept of the number of larvae destroyed in the bands. Throughout this period different types of banding material have been experimented with, but the most satisfactory material and the only material reported on in this paper is composed of 10 oz. burlap folded twice giving four thicknesses about four and one half inches wide. All bands have been inspected by crews under the supervision of this office. In Table 1, giving the efficiency of banding, the total population and the probable error has been calculated in the manner previously reported by the author (1). A segregation has been made between old and young trees due to the rougher bark and pruning scars which lowers the efficiency of bands on the older trees. Trees up to 12 years of age are classified as young, the old trees range up to 50 years of age.

TABLE 1. EFFICIENCY OF BANDING 1926–1933

OLD ORCHARDS

Year	Acres	Production Total	Production Per Acre	Per cent wormy	Pounds wormy Total	Pounds wormy Per Acre
1926	204.75	122,320	597	1.97±0.24	2,400.0± 293.6	11.7±1.4
1927	228.75	620,819	2,714	0.78±0.12	4,806.0± 745.0	21.0±3.3
1928	975.75	1,548,882	1,587	1.01±0.08	15,668.0±1,239.1	16.1±1.3
1929	1,185.50	3,809,705	3,214	0.85±0.06	32,459.0±2,285.8	27.4±1.9
1930	2,036.25	3,220,518	1,582	1.48±0.08	47,826.0±2,576.4	23.6±1.3
1931	2,589.75	2,280,261	880	6.27±0.21	142,996.0±4,788.5	55.2±1.8
1932	1,557.00	4,038,040	2,593	0.91±0.07	36,704.0±2,826.6	23.6±1.8
			YOUNG ORCHARDS			
1931	938.00	261,600	279	3.81±0.37	9,963.0± 967.9	10.6±1.0
1932	2,008.50	1,368,983	682	0.14±0.02	1,959.0± 273.8	1.0±0.1
1933	1,715.50	1,321,416	770	0.23±0.04	2,974.0± 528.6	1.7±0.3

OLD ORCHARDS (Continued)

Year	Population codling moth Total	Population codling moth Per acre	Destroyed by bands Total	Destroyed by bands Per acre	Per cent efficiency of bands Mean	Maximum	Minimum
1926	98,400± 12,038	480.6± 58.8	7,294	35.6	7.4	8.4	6.6
1927	197,046± 30,545	861.4±133.5	5,650	24.7	2.9	3.4	2.5
1928	642,388± 50,803	658.4± 52.1	41,900	42.9	6.5	7.1	6.0
1929	1,330,819± 93,718	1,122.6± 79.1	68,707	58.0	5.2	5.5	4.8
1930	1,960,866±105,632	963.2± 51.9	100,058	49.1	5.1	5.4	4.8
1931	5,862,836±196,329	2,263.9± 75.8	361,364	139.5	6.2	6.4	6.0
1932	1,504,864±115,891	966.5± 74.4	58,454	37.5	3.9	4.2	3.6
Average					5.3	5.8	4.9
			YOUNG ORCHARDS (Continued)				
1931	408,483± 39,684	435.4± 42.3	127,068	135.5	31.1	34.4	28.3
1932	80,319± 11,226	40.0± 5.6	16,275	8.1	20.2	23.5	17.7
1933	121,934± 21,673	71.1± 12.6	19,517	11.4	16.0	19.5	13.6
Average					22.4	25.8	19.9

Errors in the calculated per cent efficiency for banding are known to occur and are as follows:—

A. Errors tending to *depress* calculated efficiency under actual efficiency;

1. The assumption is made that the total population remains in the orchard, however some larvae are not mature at harvest time but are feeding on the kernel of the walnut and are removed with the crop from the orchard. They are included in the population estimate although the larvae do not have an opportunity to enter bands.

2. Dead larvae under bands are not counted. There is a greater mortality of larvae under bands than elsewhere on the tree due to the ease with which predators can find them. There is also a small mortality between the time the larvae leave the walnuts and find hibernating quarters.

3. The human error of overlooking some larvae in the bands.

B. Errors tending to *elevate* calculated efficiency over actual efficiency;

1. Blighted walnuts, which are wormy, fall early and are not harvested. The bands are, however, available to the larvae for hibernation.

2. Walnuts are not classified as wormy unless the kernels are worm injured. A variable percentage of larvae do not reach the kernel but feed only on the hull of the walnut.

3. Band inspection starts in November and ends in March. There would be a natural mortality before the emergence of the adult. Therefore some larvae that are counted and destroyed at inspection time, would normally die.

4. The factor 41 used to convert pounds to individuals (41 nuts =

1 lb.) is low. Only in one year was the average 41, some years it has been as high as 48. The average for all years would be about 44.

An evaluation of these errors will show that the degree of accuracy of the method followed is sufficient for this study.

The destruction of a small number of individuals will hold a population static when the environmental resistance is almost equal to the biotic potential. The question at issue, "Is elevating the enviromental resistance by destroying 5.3 or 22.4 per cent of the total population of any significance in controlling the codling moth?", can be answered if the annual population build up factor is known. An approximation of this factor can be obtained from the data in Table 3 (1). The pounds wormy per acre for the year under consideration when divided by the pounds wormy for the *same* orchards for the previous year will give the build up factor. Only the check orchards are used as the normal build up factor without artificially increasing the enviromental resistance is desired. The build up factor for 1932 and 1933 was determined similarly. This calculated build up factor is slightly lower than the actual due to the orchards being banded.

TABLE 2. BUILD UP FACTOR FOR CODLING MOTH ON WALNUT IN VENTURA COUNTY, CALIFORNIA

1927	1.64	1931	6.46
1928	1.22	1932	1.97
1929	4.55	1933	1.36
1930	2.06	Average	2.75

With the build up factor known the per cent efficiency of any control measure needed to hold the population static can be calculated.

$$C = \frac{B}{A} \qquad X = 100\,\frac{(B-C)}{B}$$

If A is the annual build up factor; B, is the initial population; C, is the residue population after control measure; X, is the per cent efficiency needed to hold the population static. When A is equal to 2.75, X has a value of 63.6.

With an initial population of 10 codling moth and a build up factor of 2.75, by the end of the 4th year a population of 572.0 will be reached. Assuming that bands are placed on the trees at this time the influence they would exert on the population trend is shown in Table 3.

TABLE 3. EFFECT OF BANDING ON POPULATION TREND

End population (4th year)	Per cent destroyed in bands	Residue population (4th year)	End population (5th year)
572.0	0.0 no bands	572.0	1573.0
572.0	5.3 old trees	541.0	1489.7
572.0	22.4 young trees	443.9	1220.7
572.0	63.6 X	208.2	572.6

Needless to say, this is a very poor showing for bands.

The question arises as to the band efficiency on apples and pears. No information is at hand to answer this question, but it is hoped that workers in this field will publish data of this nature. In view of the varying success of codling moth control, it would be of great interest to learn the build up factor in different localities on various host plants. The writer has been unable to locate any information on this subject in the literature nor is the published field data such that the build up factor can be calculated.

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A LABORATORY SPRAY APPARATUS

By E. H. SIEGLER and FRANCIS MUNGER, *Bureau of Entomology, U. S. Department of Agriculture*

Some interest has been shown in the specifications of a homemade laboratory sprayer used in connection with the apple-plug method of testing insecticides against newly hatched codling moth larvae. This apparatus has also been employed in spraying foliage in tests against other insects. In view of the possible value of the apparatus to other entomologists, the authors have prepared the present paper.

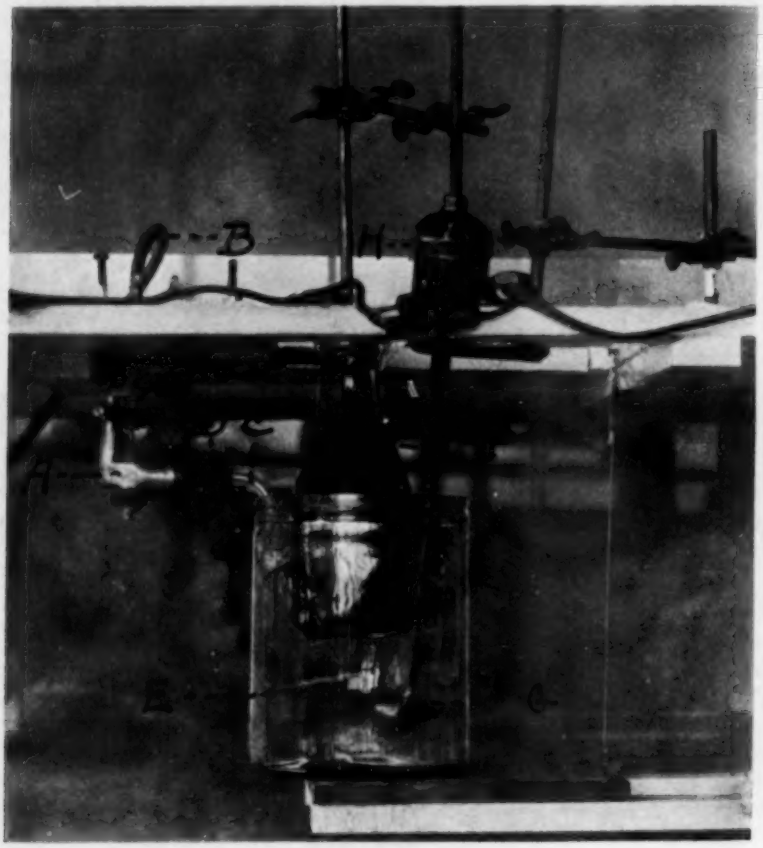

FIG. 104.

SPRAYER.—The sprayer (Fig. 104, A) is a compressed-air apparatus designed originally for the painting of automobiles. The air is supplied by means of an air compressor, electrically driven, under a working pressure for our work of 25 pounds per square inch. A flexible cloth-fabricated hose (Fig. 104, B) is used to conduct the air from the compressor to the sprayer. The spray material is sucked through a short glass tube (Fig. 104, C) which is attached to the sprayer by means of a short piece of rubber tubing (Fig. 104, D). The spray output is about 103 cubic centimeters per minute.

AIR COMPRESSOR.—Any small power-driven compressor, capable of developing a pressure of 25 pounds per square inch will serve the purpose. Small compressors, supplying 2 cubic feet of air per minute at 40 pounds' pressure, are available at a cost of about $12.

CONTAINER FOR INSECTICIDE.—In our own work an ordinary glass battery jar (Fig. 104, E) holding a gallon of spray material was used.

DISPLACER.—In order to hold the spray material at the same level during successive tests, a displacer (Fig. 104, F) is pushed down into the spray material and its position is adjusted by hand at intervals so as to keep the level of the spray material to the proper height. An ordinary quart milk bottle served as a displacer.

AGITATOR.—Thorough agitation of the spray material is obtained with a 3-blade bronze propeller, 2 inches in diameter (Fig. 104, G), attached to a bronze shaft which is operated by means of a small induction motor (Fig. 104, H). The speed of the propeller is governed with a rheostat (Fig. 106, I). The shaft is inserted at an angle and off center in order to prevent centrifugal movement of the spray material.

CONVEYOR BELT.—A leather conveyor belt (Fig. 105, J), 3 inches wide and 121 inches long, is used to carry the objects to be sprayed

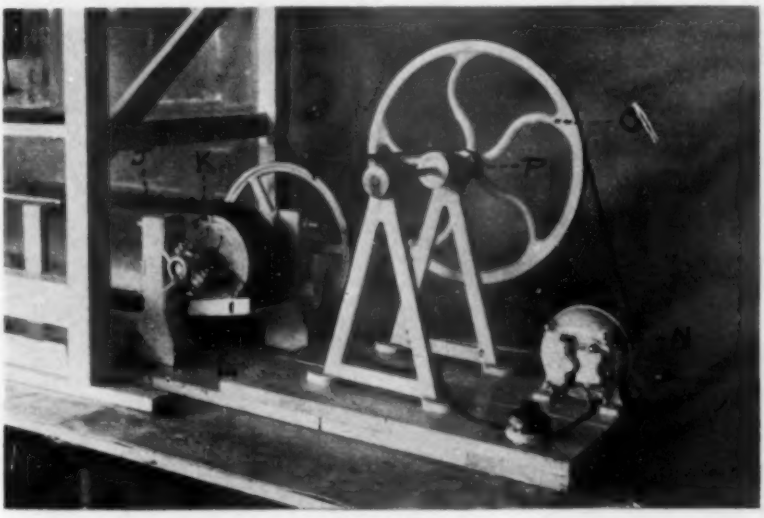

FIG. 105.

through the spray as it is forced out of the spray nozzle. The belt operates at a speed of about 1 foot per second. A guard of round leather belting (Fig. 105, K), ¼ inch in diameter, is attached to each edge of the conveyor belt to hold in place the wooden rack for the apple plugs on the moving belt. The guard belting is attached to the conveyor belt with small metal staples.

BELT PULLEYS.—The wooden, split pulleys (Fig. 105, L), 6 inches in diameter by 3¼ inch face, were used in connection with the conveyor belt. The pulleys are attached to steel shafts, 1 inch in diameter, which are held in place by split post blocks, one of which is shown (Fig. 105, M).

DRIVING MOTOR.—The conveyor mechanism was driven with a 1/20 horse power, synchronous electric motor having 1725 R.P.M. (Fig. 105, N), equipped with a grooved pulley, 2¼ inches in diameter for a ¼ inch round belt.

REDUCING PULLEYS.—In order to reduce the speed of the conveyor belt to about 1 foot per second, 3 additional grooved pulleys, 16 inches (Fig. 105, O), 2 inches (Fig. 105, P), and 12 inches (Fig. 105, Q) in diameter, are used.

SPRAYER HOUSING.—The sprayer is housed within a wooden frame 46 inches long, 20 inches wide, and 29 inches high (Fig. 106, U). For our own work only the rear side was covered with glass. If, however, the spray apparatus is exposed to wind currents, all sides can be enclosed in glass, a movable glass door being used on the front side.

DRIP PAN.—A movable galvanized pan (Fig. 106, R) is used to catch the excess spray material.

RECEIVING PLATFORM.—A wooden platform (Fig. 106, S) is used to receive the sprayed objects. The rack (Fig. 106, T) holding the objects to be sprayed is transferred automatically from the conveyer belt to the receiving platform.

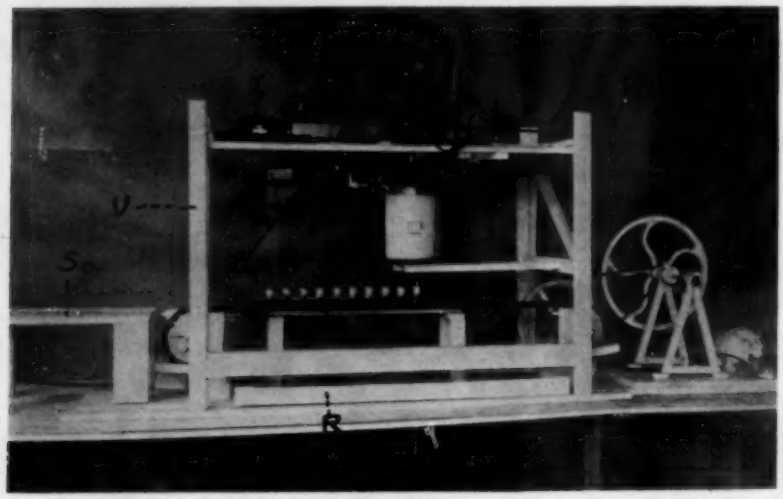

FIG. 106.

FURTHER STUDIES ON DEVIL'S SHOE-STRING, *CRACCA VIRGINIANA* LINN.[1]

By V. A. LITTLE, *Texas A. & M. College, College Station, Texas*

In 1931 the initial results of a study of the insecticidal properties of Devil's shoe-string, *Cracca virginiana*, was published. It was shown in this study that the plant has considerable possibilities as an insecticide, but that its toxicity is extremely variable, and as a whole is too low to use it for commercial purposes. In 1933 Dr. E. P. Clark of the Bureau of Chemistry and Soils, U. S. Department of Agriculture, after making a chemical study of this plant reported the occurrence of rotenone and three other compounds in its roots.

It was soon realized that if this plant were to be developed into a commercial product, it would be necessary to grow it under field conditions, and a product high and uniform in toxicity would have to be developed. This has been the objective of this investigation for the past three years. A survey of the Southwest has been made, the ecology of the plant has been studied, numbers of samples have been collected, and preliminary tests have been conducted to ascertain the regions yielding the most toxic material. In addition samples from other parts of the United States have been examined.

The plant grows in any well-drained soil. The most toxic samples are found in sandy soils, but not all plants growing in sand possess toxic qualities, in fact, most are worthless.

It is found growing only where competition with other vegetation is not too great, as it is crowded out by dense plant growth. The best way to locate it where it is relatively scarce is to examine the right-of-way of railroads and highways. The banks and fills offer drainage suitable for its growth. Competition is lessened by periodically destroying other vegetation through cutting or burning, while this plant is not seriously injured when once its root system is developed. New growth begins immediately when the stems are destroyed. In fact, two crops of seed may be produced in one season by cutting back the plants after the first crop matures. This may be found to be of value in accelerating the growth of the root system, thus artificially producing a second growing cycle.

New growth arises in the spring from adventitious buds on the crown. Blooming normally occurs in the spring. The pods mature and begin to burst in early July. They burst with a clearly audible sound, and the seeds are scattered in this way.

As a result of the ecological studies, a sandy hillside was selected for our experimental plats. Here the most toxic strains are being grown. The plant may be propagated from either the roots or the seeds. Propagation from roots produce larger plants in a given length of time, but the cost and labor of producing them by this method is greater than growing them from seeds.

[1]Contribution No. 29, Department of Entomology, Texas A. & M. College, College Station, Texas.

FIG. 107.—Devil's Shoe-string, *Cracca virginiana*, age 15 months. Grown from root stock.

The soil should be bedded with the rows three and one-half to four feet apart. The plants should be about three feet apart in the rows. If the roots are transplanted it is done best in February. The crown is broken up to make several plants out of one. New growth arises from the crown and if a root does not have a portion of it, it is worthless. Roots smaller than one-fourth inch in diameter should not be used. They should be buried to a depth of four to six inches with the crown near the surface of the soil.

The easiest method of propagation is from seeds if an adequate supply can be obtained. Blister beetles and other insects feed upon the buds, flowers, and immature seed pods. A large number of the seeds are destroyed by weevils and a small caterpillar. In addition many seeds are lost as the pods burst as soon as they are fully mature. The seeds must be scarified before planting. Fair results have been obtained by soaking them for fifteen minutes in concentrated sulphuric acid. They are planted after the dangers of frost are past. They should be planted rather thickly to insure a satisfactory stand and then thinned if necessary. Cultivation should be shallow so as not to disturb the root system and at such intervals as is recommended for the average row crop. Considerably more cultivation is required the first year than the second.

At least two years are required to produce a satisfactory root system. The roots should be harvested in late summer or early fall and sun-dried. They may lose as much as 40 to 50 per cent of their weight in drying. Plowing them out with a turning plow or a middle-breaker appears to be the most practical method of harvesting. Harvesting

FIG. 108.—Devil's Shoe-string, *Cracca virginiana*, age 27 months, grown from root stock.

the roots will probably be one of the most difficult problems in developing the plant into a commercial product. It is not at all uncommon to find individual plants yielding as high as one pound of dried roots, the average however is considerably less. This plant can easily produce as many pounds of roots per acre as derris. It may be grown on marginal land; it may be produced for a few cents per pound. This is a nitrogen-fixing legume; it is a soil builder. The stems and leaves have some value as hay. There is an attempt at the present time to develop another species, *Cracca lindheimeri*, indigenous to southwest Texas, into a forage crop.

The behavior of the plant under cultivation is interesting. Its growth compared to that in nature is phenomenal. Bunches may be grown in two seasons as large as those estimated to be ten or more years of age in the uncultivated state. It even varies in its taxonomic characteristics. Normally, it is characterized by simple erect, tufted stems, about 18 inches in height, but under cultural conditions the stems may grow to twice that height, and, particularly toward the end of the season, tended to fall to the ground and to branch. Marked variations appear, indicating different varieties or strains, and in some instances perhaps different species. In all probability new varieties and perhaps new species will be discovered in these studies as well as some synonymy. Our work at the present time is conducting physiological tests on these plants, eliminating the poor and growing the best. The results are encouraging.

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HOMOLOGS OF PARIS GREEN

I. LOWER MEMBERS OF ACETIC ACID SERIES

By F. E. DEARBORN, *Insecticide Division, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Washington, D. C.*

HOMOLOGS OF PARIS GREEN.—Copper aceto-arsenite, or Paris green, has been a commercial product for nearly a century. Its principal use prior to 1870 was as a pigment. The product manufactured for use as a pigment was fairly uniform, but that used subsequently as an insecticide varied considerably in composition (1). The insecticide as manufactured today, however, is very uniform. Paris green was the first arsenical successfully used for poisoning insects on growing plants, and it came into wide use in poisoning the Colorado potato beetle and other insects before the introduction of lead arsenate as an insecticide. It has been largely replaced by other insecticides less dangerous to growing plants when mixed with water in spray application, but it is still widely used in other methods of application.

The first contribution to the chemistry of Paris green was made by Liebig (2), and the first definite statement in regard to its composition was made by Ehrmann (3), who found it to consist of three molecules of copper meta-arsenite crystallized with one molecule of copper acetate. Abrahams (4) found that formic, butyric and valeric acids could be substituted for acetic acid in the molecule. Wöhler (5), however, had stated that a butyric green prepared by him contained only two molecules of copper meta-arsenite united with one molecule of copper butyrate. In comparatively recent years some doubt has been expressed as to whether Paris green of a definite composition can be made (6). In 1906 Avery (7) in the course of an extended investigation of this general class of compounds prepared and analyzed a series of greens in which formic, propionic, butyric, monochloracetic and trichloracetic acids were substituted for acetic acid. His conclusions were that Paris green and those homologs that were studied are compounds of copper meta-arsenite and the copper salt of the acid used in which the ratio most frequently approaches three molecules of copper meta-arsenite to one molecule of the copper salt of the acid, but in some cases more closely approximates two to one. The object of the present investigation was to veryify Avery's conclusions as to the composition of the homologs of Paris green and to investigate their properties as insecticides.

PREPARATION OF THE GREENS.—The greens were prepared in two

different ways. The first method was that used by Avery (7). As the copper salts of the acids under investigation are soluble in water, an excess of freshly precipitated copper hydroxide was added to the fatty acid and the excess hydroxide filtered off. Arsenious oxide was dissolved in boiling sodium hydroxide solution, phenolphthalein indicator added, and the color discharged by adding the fatty acid. The solutions were heated to about 70–80° C. and mixed in such proportions that the molecular ratio $CuO:As_2O_3$ ranged from 5:4 to 2:1; the ratio in Paris green is of course 4:3. In preparing the trichloracetic green, however, the solutions could not be used much above room temperature as trichloracetic acid is easily decomposed when heated with an alkali. The second method employed consisted of mixing a hot solution of the sodium salt of the fatty acid with a hot solution of sodium arsenite, and to this mixture adding a solution of copper chloride of approximately the same temperature. Varying proportions of the salts were used as in the first method. In preparing the trichloracetic green no solution was over 25° C.

The freshly precipitated greens, with the exception of the trichloracetic compound, were heated to about 100° C. before they were set aside for completion of the reaction. They were olive green, but upon standing in the mother liquor assumed the characteristic bright green color. It was found that the mother liquor should have an acid reaction to blue litmus paper, for if it is alkaline an unsatisfactory green will be formed. Greens containing the following fatty acids were made by both methods: formic, acetic, propionic, butyric, monochloracetic, dichloracetic and trichloracetic. When the greens had assumed their characteristic color, they were filtered and washed with warm water until the washings gave no color when tested with ammonium hydroxide. They were then dried at 100° C. and analyzed. The greens made by the two methods gave practically identical results on analysis.

Methods and Results of Analysis.—The analytical methods employed were those given in the A.O.A.C. Book of Methods (8). The total arsenic was determined by the hydrazine sulphate:sodium bromide distillation method and the copper by the thio-sulphate method. The volatile fatty acids were determined by the xylene distillation method (9).

The analytical results on the series of greens made without purification showed that in all cases the arsenic content was lower than that required by the formula, $3CuAs_2O_4.Cu(Acid)_2$, the effect being most noticeable in the higher homologs and in the substituted chloracetic compounds; that the copper content, with the exception of the butyric compound, was higher than required by theory; and that the anhydrides of the acids were also too high. Since all the greens were prepared from technical reagents and other compounds were present in the mother liquor during the formation of the compounds, it is only natural that they should be contaminated with impurities. As recrystallization could not be resorted to, other methods of purification were necessary. They were first subjected to a process of purification used by Avery (7). This treatment did not render them pure, although it did increase their

TABLE 1

Name of green	Theoretical composition 3CuAs$_2$O$_4$.Cu(Acid)$_2$			Purified by Avery's method			Results from analysis After further extraction with CCl_4			Analyses from Avery's work		
	Total As as As$_2$O$_3$ Per cent	CuO Per cent	Anhy. of acid Per cent	Total As as As$_2$O$_3$ Per cent	CuO Per cent	Anhy. of acid Per cent	Total As as As$_2$O$_3$ Per cent	CuO Per cent	Anhy. of acid Per cent	Total As as As$_2$O$_3$ Per cent	CuO Per cent	Anhy. of acid Per cent
Formic	60.22	32.28	7.50	59.85	32.44	7.53	60.08	32.34	7.58	59.78	32.28	7.70
Acetic	58.55	31.39	10.06	57.99	31.69	10.33	58.24	31.42	10.29	57.55	31.75	10.31
Propionic	56.98	30.54	12.48	55.54	31.11	12.90	55.32	30.90	12.90	56.66	30.37	12.91
Butyric	55.49	29.74	14.77	52.99	29.63	16.90	54.06	29.74	15.88	54.00	29.55	16.33
Monochloracetic	54.83	29.39	15.78	52.89	30.69	15.81	53.84	30.17	15.82	52.96	———	———
Dichloracetic	51.54	27.63	20.83	50.53	28.14	20.94	51.36	27.62	20.99	———	———	———
Trichloracetic	48.63	26.07	25.30	47.31	27.36	25.33 (by dif.)	47.33	27.41	25.26 (by dif.)	47.27	———	———

purity to a slight extent. As the copper and the anhydride content of these purified greens were in excess of the theoretical amounts in all cases, with the exception of the butyric green, it was believed that the copper salt of the fatty acid used (or the copper salts of higher homologous fatty acids contained in it) and perhaps some fatty matter were present and were not removed by Avery's method of purification. As warm carbon tetrachloride has been found to be a fairly good solvent for copper salts of the higher fatty acids, the greens were extracted with this solvent in a Soxhlet apparatus for 3–4 hours. This treatment increased their purity considerably, in some instances making them closely approach the theoretical composition. It was found, however, that if some of the greens were extracted for too long a time they were slowly oxidized and otherwise decomposed. This was most noticeable in the propionic and trichloracetic compounds. The analytical results obtained on the compounds purified by Avery's method and after extraction with carbon tetrachloride are given in Table 1. Avery's results are also tabulated for comparison.

Considering the circumstances under which the greens were prepared, the difficulty of obtaining pure substances, and the limits of analytical accuracy, the analyses seem to point clearly to the fact that Paris green and its homologs are definite compounds of copper meta-arsenite and the copper salt of the corresponding acid, and that the ratio of the two constituents is very close to 3 : 1 in all cases. The deviation from the theoretical composition of the compound is undoubtedly due to impurities which are occluded or intermixed with the compound in the formation of the complex molecule. The impurities that are most likely to be present are copper salts of the fatty acids and other water-insoluble substances that may be formed from impurities present in the original ingredients.

Toxicity.—A few laboratory toxicity tests on culicine mosquito and southern army worm larvae were conducted with the compounds that had been purified by extraction with carbon tetrachloride.* The results indicate that some of the compounds are slightly more effective than Paris green. It is believed that the physical condition of these materials can be improved, and when more definite toxicity data concerning the improved compounds are available they will be published by the cooperating entomologists.

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BARIUM FLUOSILICATE AS A CONTROL FOR CABBAGE WORMS (*PIERIS RAPAE* L.)

By V. R. DIAMOND, *Purdue University Agricultural Experiment Station*

Tests carried out in the past two years (1932–1933) under the direction of the Department of Entomology of the Purdue University Agricultural Experiment Station have indicated that barium fluosilicate is an excellent killing agent for cabbage worms. Results for both seasons show a marked superiority for barium fluosilicate combinations over the lead arsenate-lime 1:10 dust. The experiments were carried out on large plots of cabbages in truck gardens at Lafayette and Indianapolis under very favorable experimental conditions. The natural infestation was very heavy and uniform on these plots in both 1932 and 1933 and rainfall was not a factor of importance.

MINIMUM CONCENTRATION.—Tests in which barium fluosilicate[1] was diluted with various inert carriers indicate that one part of barium fluosilicate with four parts of diluent is the most efficient mixture. Of the diluents used hydrated lime is preferred because of its cheapness, easy accessibility and good dusting qualities, although the use of lime seemed to decrease slightly the toxicity of the poison. Clay, flour or talc, however, are good.

DOSAGE PER ACRE.—Although most workers recommend dusting cabbages at the rate of 20 to 40 pounds per acre, according to the size of the plants, it was found that a heavier application is necessary on the closely spaced plantings in the commercial truck gardens. For plants approaching maturity dust applications of 50–70 pounds of diluted dust per acre was found to be satisfactory.

RESIDUE AVOIDANCE.—Experiments have shown that arsenical or fluosilicate dusts may be applied up to within two weeks of marketing time without any fear of poisonous residue, provided the loose outer leaves are stripped off before sale. This is an accepted practice among the growers in Indiana as it gives the product a much better appearance on the market. By an elaborate system of punch markings following dust applications on one large plot all the leaves in the cabbage heads which received any trace of insecticide dust were marked. This was done in such a way as to indicate also the time of the dust application. At the time when the first heads were prepared for market by the grower, notes were kept to indicate the percentage of cabbage heads with punch marks indicating the presence of residue, which would normally reach the market. Not only were all the marked leaves stripped

[1]Barium fluosilicate used in these experiments is the material on the market known as Dutox which is 80 per cent barium fluosilicate and 20 per cent inert carrier.

off and discarded but invariably one of two whorls of leaves inside the exposed leaves were also removed. Due to the complete covering of the head by each whorl of leaves there is no possibility of any dust reaching the inner part of the cabbage head by the action of rainfall. Since there is little danger of cabbage worm injury after the heads have become six or seven inches in diameter, dusting the plants up to this stage of maturity will in the majority of cases give excellent control even in heavily infested areas. In view of these results there seems to be no possible objection to the use of arsenicals or barium fluosilicate dusts because of residue danger, provided, of course, that the loose outer leaves are stripped off in the usual fashion.

COMPARISON OF EFFECTIVENESS.—Barium fluosilicate showed a definite margin of effectiveness over arsenate of lead-lime 1:10 in both 1932 and 1933. Careful examination showed that the barium fluosilicate dust killed the cabbage worms more rapidly. In many cases it was noted that the arsenical dust had a repelling effect on the worms and some of them were able to migrate to some undusted portion of the plant and thus escape the insecticide application.

A brief summary of the results for the two seasons is as follows:

SUMMARY RESULTS—1932[1]

Material	No. of experiments	Total plots	Average plants per plot	Average per cent control
Barium fluosilicate	5	7	50	97.6
Barium fluosilicate-flour 1:1	5	7	50	96.2
Barium fluosilicate-talc 1:1	5	7	50	89.4
Barium fluosilicate-lime 1:1	5	7	50	80.1
Barium fluosilicate-talc 1:10	5	7	50	66.7
Lead arsenate-lime 1:10	5	7	50	72.9

SUMMARY RESULTS—1933[1]

Material	Number of experiments	Total plots	Average plants per plot	Average per cent control
Barium fluosilicate	3	4	150	97.0
Barium fluosilicate-clay 1:1	1	3	150	98.7
Barium fluosilicate-clay 1:4	1	3	150	96.0
Barium fluosilicate-lime 1:4	2	5	150	94.2
Barium fluosilicate-flour 1:4	2	5	150	92.4
Lead arsenate-lime 1:10	3	5	150	66.4

[1]The figures in these tables refer to four applications in each season for all materials.

1934 EXPERIMENTS WITH NEWLY DEVELOPED TYPES OF OILS FOR CODLING MOTH CONTROL

By C. R. CLEVELAND,[1] *Chicago, Illinois*

Knight and Cleveland (1) in 1934, reported the results of fundamental studies and tests, extending over approximately a three year period, of a new type of summer oil spray. Evidence accumulated at the time

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of that publication showed that these new oils, called for want of a better designation "soluble or emulsible oils," exhibit distinctive physical properties in regard to spreading, oil deposit, thickness of film, and retardation of rate of penetration into leaf and fruit tissue, as compared to the usual types of summer oil theretofore developed and generally available; namely, the inert mayonnaise or cream emulsion oils or the tank-mix oils. Field tests on codling moth and pear psylla in 1933 yielded convincing evidence of the superior efficiency of the new "soluble" oils in control of these insects.

The new oils were developed further in 1934. Summer field tests were preceded by laboratory studies and greenhouse experiments. A comprehensive range of new compounds of a chemical type similar to those previously found to exert a marked and desired influence on oil spread, film thickness, deposit and surface persistence, were incorporated in various kinds of oil, and were subjected to tests to determine their performance in respect to the properties outlined above.

From this were selected three formulae indicating the most promising possibility of possessing those properties which would show a maximum degree of effectiveness, as well as practicability in handling. These three oils were then subjected to thorough field tests in two midwest apple orchards showing heavy infestations of codling moth.

A description of the essential characteristics of these three oils follows:

Oil A.—95% Technical White Oil of 80–85 seconds Saybolt viscosity at 100° F. with an electrolytic metallic napthenate salt dissolved in the oil (1).

Oil B.—95% Technical White Oil (same as in Oil A), with a combination of an hydroxy ester of oleic acid and a metallic napthenate salt dissolved in the oil (1).

Oil C.—95% of the same white oil as that in Oils A and B, with the same combination of ester and salt as in Oil B, but in slightly different proportions.

The most noticeable characteristic of all the new oils is their relatively clear and completely liquid oily appearance and consistency, in marked contrast to the opaque, thick, creamy or paste-like appearance and consistency of the inert mayonnaise type of summer oils heretofore available. The new oils contain no water, while the mayonnaise summer oils contain from about 15 to 35% water.

In use, Oil A, containing ingredients possessing almost no emulsifying power, must be emulsified by use of an added emulsifier in the tank, such as calcium caseinate. Oils B and C contain emulsifiers that eliminate the necessity for the use of added tank emulsifiers.

Field Tests

The major objectives of the tests were as follows:

1.—Relative efficiency of the new oils compared to paste emulsions and miscible oils, as:

   a.—combined with arsenate of lead

   b.—combined with nicotine

2.—Safety of the new oils vs. pastes with lead and nicotine.

3.—Effect on residue loads and removal.
4.—Determination of the most effective and practicable formula.
5.—Determination of the most practicable schedule of use.
6.—Determination of the relative costs and returns from different methods of use as compared to arsenate of lead alone.

TEST ORCHARD NO. 1. *H. W. Ringhausen, Hamburg, Illinois*

Jonathan trees, 29 years old, were selected for test. This orchard shows a history of heavy codling moth infestation and severe injury during the past six or seven years. In 1934, the Jonathan crop was heavy. An eight acre block in the most heavily infested part of the orchard was divided into 12 duplicated plots, each receiving a different treatment. The duplicates were staggered in such a way as to place them well apart from each other and to subject the entire treatment to a representative range of insect, tree and location influences. One duplicate consisted of a plot three rows long and three rows wide (9 trees); the other of a plot 3 rows wide and 4 rows long (12 trees).

A very complete project was carried out in this orchard, including emergence cage and bait trap observations daily as a basis for timing the sprays; frequent inspections for egg deposition, worm attack, control results and spray injury; hourly temperature records; periodic examinations to determine the extent of dropping in the various plots and the per cent of worm injury on dropped fruit; final counts of worm and spray injury on harvested fruit; and residue loads and removal results from representative plots.

SCHEDULE OF TREATMENTS.—All plots received the same treatment in the calyx spray, namely liquid lime sulphur (1–50); arsenate of lead (4–100); and spray lime (4–100).

The seven following cover sprays were timed according to bait trap and other observations of moth activity. The concentration of materials used in each application was regulated according to moth activity and observation of preceding worm and spray injury. Hydrated (high calcium) spray lime was used in all applications containing arsenate of lead, at a constant strength of 1½ pounds for each pound of lead. Hence, in the spray schedule given below, the lime is omitted for purposes of brevity.

IDENTIFICATION OF MATERIALS USED BY ABBREVIATED SYMBOLS

L — Arsenate of Lead
NS—Nicotine sulphate (40%)
Oil A—See description of new oils in "Introduction."
Oil B— " " " " " " "
Oil C— " " " " " " "
Oil D—Miscible or soluble dormant oil (Soap type)
Oil E—Summer Spray Oil Emulsion (Mayonnaise type), with same base white oil as in Oils A, B and C.

The schedule of applications of the seven cover sprays is given in the following table. The number opposite each material refers to pounds per 100 gallons of spray for lead; gallons per 100 for oil; and pints per 100 for nicotine.

SCHEDULE OF SPRAY APPLICATIONS

Plot No.	First brood		Second brood			Third brood	
	May 17–18	May 29–31	June 13–14	July 2–3	July 13–14	Aug. 6–7	Aug. 23–24
1	L — 4	L —4	L —4	L —4	L —4	L — 3	L — 3
2	Oil D—½	Oil D—1	Oil D— ¾	Oil D— ¾	Oil D— ¾	Oil D—½	Oil D—½
	L — 4	L —4	L —3½	L —4	L —4	L — 3	L — 3
3	Oil A—½	Oil A—1	Oil A— ¾	Oil A— ¾	Oil A— ¾	Oil A—½	Oil A—½
	L — 4	L —4	L —3½	L —4	L —3	L — 3	L — 3
4	Oil C—½	Oil C—1	Oil C— ¾	Oil C— ¾	Oil C— ¾	Oil C—½	Oil C—½
	L — 4	L —4	L —3½	L —4	L —3	L — 3	L — 3
5	Oil D—½	Oil E—1	Oil E— ¾	Oil E— ¾	Oil E—1	Oil E—¾	Oil E—½
	L — 4	NS —1	NS — ¾	NS —1	NS —1	NS — 1	L — 3
6	Oil E—½	Oil E—1	Oil E— ¾	Oil E—1	Oil E—1	Oil E—¾	Oil E—½
	L — 4	L —4	L —3½	NS —1	NS —1	NS — 1	NS — 1
7	Oil A—½	Oil A—1	Oil A— ¾	Oil A— ¾	Oil A— ¾	Oil A—¾	Oil A—½
	L — 4	L —4	L —3½	NS —1	NS —1	NS — 1	NS — 1
8	Oil C—½	Oil C—1	Oil C— ¾	Oil C— ¾	Oil C— ¾	Oil C—¾	Oil C—½
	L — 4	L —4	L —3½	NS —1	NS —1	NS — 1	NS — 1
9	Oil D—½	Oil A—1	Oil A— ¾	Oil A— ¾	Oil A—1	Oil A—¾	Oil A—½
	L — 4	NS —1	NS — ¾	NS —1	NS —1	NS — 1	L — 3
10	Oil C—½	Oil C—1	Oil C— ¾				Oil C—½
	L — 4	L —4	L —3½	Oil C—1½	Oil C—1½	Oil C— 1	L — 3
11	Oil A—½	Oil A—1	Oil A— ¾				Oil A—½
	L — 4	L —4	L —3½	Oil A—1½	Oil A—1½	Oil A— 1	L — 3
12	Oil D—½	Oil C—1	Oil C— ¾	Oil C— ¾	Oil C—1	Oil C—¾	Oil C—½
	L — 4	NS —1	NS — ¾	NS —1	NS —1	NS — 1	L — 3

Note.—On plots 5, 9, 10, 11 and 12, where, as will be seen, the original intention was to use oil-nicotine in all sprays following the first cover or to use oil alone at increased concentrations following the first brood, it seemed advisable to change the treatment in the last cover because, under the extreme heat and drouth conditions prevailing, indications of noticeable fruit and foliage injury appeared following the application of August 6–7.

The following table is offered to show a comparison of the average amounts or dosages of the different oils and other materials used in the various treatments on the basis of the entire schedule of seven cover sprays.

AVERAGE CONCENTRATION OF MATERIALS PER APPLICATION

Plot No.	Oil	Lead	Nicotine
1	None	3.71 lbs. per 100	None
2	.678 Gals. per 100	3.62 lbs. per 100	None
3	.678 Gals. per 100	3.47 lbs. per 100	None
4	.678 Gals. per 100	3.47 lbs. per 100	None
5	.75 Gals. per 100	1.0 lbs. per 100	.68 pint per 100
6	.785 Gals. per 100	1.63 lbs. per 100	.57 pint per 100
7	.68 Gals. per 100	1.63 lbs. per 100	.57 pint per 100
8	.68 Gals. per 100	1.63 lbs. per 100	.57 pint per 100
9	.75 Gals. per 100	1.0 lbs. per 100	.68 pint per 100
10	.964 Gals. per 100	2.04 lbs. per 100	None
11	.964 Gals. per 100	2.04 lbs. per 100	None
12	.75 Gals. per 100	1.0 lbs. per 100	.68 pint per 100

CODLING MOTH CONTROL RESULTS.—Data showing the percentage of clean, wormy and stung fruit, and the number of stings per 100 apples, obtained by detailed inspection of picked fruit at harvest, are summarized in the table given below. A total of 1500 fruits from each treatment (duplicate plots) was examined. The samples were selected in equal proportions from all sides of both top and bottom parts of two count trees in each plot.

Drop counts from the same trees as those used in the final check were made at the end of the first and second brood periods. These counts are not included in the summary given below, since a study of the drop data showed that it would have little or no additional weight on the conclusions as to the relative performance of the various treatments.

RESULTS FROM CODLING MOTH SPRAYS

Plot No.	Treatment	% Clean	% Wormy	% Stung	No. Stings per 100 Apples
1	Lead (all season)	53.0	12.1	42.8	69.9
2	Oil D plus lead (all season)	71.9	4.7	25.9	35.5
3	Oil A plus lead (all season)	89.5	0.7	9.8	11.4
4	Oil C plus lead (all season)	81.1	4.3	15.8	21.0
5	Oil D plus lead (first cover) Oil E plus nicotine (next five) Oil E plus lead (last cover)	74.7	9.3	18.3	22.3
6	Oil E plus lead (first brood) Oil E plus nicotine (2nd and 3rd broods)	69.4	10.4	23.5	31.5
7	Oil A plus lead (first brood) Oil A plus nicotine (2nd and 3rd broods)	86.4	3.3	11.0	12.5
8	Oil C plus lead (first brood) Oil C plus nicotine (2nd and 3rd broods)	83.1	3.7	14.1	16.7
9	Oil D plus lead (first cover) Oil A plus nicotine (next five) Oil A plus lead (last cover)	76.9	6.7	19.0	23.1
10	Oil C plus lead (first brood) Oil C alone (next three) Oil C plus lead (last cover)	82.4	3.5	15.2	18.7
11	Oil A plus lead (first brood) Oil A alone (next three) Oil A plus lead (last cover)	86.4	3.7	10.1	11.9
12	Oil D plus lead (first cover) Oil C plus nicotine (next five) Oil C plus lead (last cover)	73.3	7.7	21.1	26.1

The new Oil A, combined with lead throughout the season, produced the best control by a marked margin, with less than 1% worm entrance injury, and nearly complete prevention of sting injury. These results show the exceptional ovicidal efficiency of this oil. Even in those treatments where the new Oil A was used in less completely effective ways, such as alone and in combination with nicotine during a part or nearly all of the schedule, and where worm entrance control was less complete, it is significant that a consistently superior ovicidal performance is indicated. A similar, although slightly lesser efficiency in this respect, is also apparent with Oil C.

Treatments in which the new "soluble" oils may be compared directly with the conventional mayonnaise emulsion (Plots 7 and 8 with Plot 6) and with the miscible oil (Plots 3 and 4 with Plot 2) show a positive control superiority for the solubles.

SPRAY INJURY.—None of the oils combined with lead and lime throughout the season produced any apparent leaf or fruit injury greater than that on the straight lead plots. All the oils at ¾% plus nicotine in second and third brood sprays produced a little more than normal burning and a slight amount of calyx end burn. All plots treated with oil alone at 1½% showed a considerable amount of leaf burning and calyx end burning on the fruit.

The degree of injury produced by the stronger oil treatments was of course influenced greatly by the abnormally extreme climatic conditions existing in this orchard in 1934. The Jonathan is also one of the varieties most susceptible to oil injury. As an illustration of the severity of temperature conditions encountered, the following significant data may be noted:

No. days with maximum of 95° F. or over..... 52
No. days with maximum of 100° F. or over..... 37
No. days with maximum of 105° F. or over..... 21
No. days with maximum of 110° F. or over..... 9

Four spray applications had to be made on days showing a maximum temperature ranging from 101° F. to 109° F., and all four were followed by one or more days showing temperatures of 100° F. to 112° F. Drouth conditions were also severe in this orchard. Under such terrific test conditions, it is surprising that much greater injury was not produced.

Exact injury data is given in the following table:

Plot No.	Treatment	Spray Injury			
		Foliage injury	Fruit injury		
		% leaves showing burn	% fruit with calyx end burn	% fruit with side sunburn	% fruit with browned and enlarged lenticels
1	Lead (all season)	7.5	0.0	4.4	0.0
2	Oil D plus lead (all season)	10.6	0.0	9.0	0.2
3	Oil A plus lead (all season)	7.3	0.0	4.0	0.2
4	Oil C plus lead (all season)	8.7	0.0	5.2	1.2
5	Oil E plus nicotine (most of season)	17.7	9.6	7.0	0.6
6	Oil E plus lead (first brood) Oil E plus nicotine (later sprays)	15.6	4.0	5.6	0.0
7	Oil A plus lead (first brood) Oil A plus nicotine (later sprays)	4.3	5.2	5.6	0.4
8	Oil C plus lead (first brood) Oil C plus nicotine (later sprays)	19.5	4.6	7.0	0.2
9	Oil A plus nicotine (most of season)	22.0	16.4	8.6	1.4
10	Oil C alone at 1–1½% (3 covers)	46.7	10.4	13.2	5.4
11	Oil A alone at 1–1½% (3 covers)	45.4	21.8	19.4	12.0
12	Oil C plus nicotine (most of season)	27.9	7.0	11.6	1.8

Type of Spray Coverage—Effect on Color

Oil-Lead Combinations.—Miscible Oil D produced the most uniform and smooth coverage. It was a practically perfect even film type, with no spot or blotch-like appearance. Oils A and C were equivalent, with a partly blotch-like coverage and partly smooth, even film, but little or no strong spot type effect. It was intermediate between Oil D and Oil E (mayonnaise emulsion), which produced a typical strongly spot or blotch-like effect.

The color of fruit sprayed with Oil D was superior, being uniform and very good for the season. It was equal to straight lead, and showed no color spots. The color of fruit sprayed with Oils A and C was nearly equal to Oil D. An occasional apple showed a very few faint color spots, of no commercial significance. The color of fruit sprayed with Oil E was not uniform, showing the color spots produced by the spotted coverage that are characteristic of this type of oil with lead on this variety.

Oil-Nicotine Combinations.—Both new Oils A and C, on plots 7 and 8, sprayed with oil-nicotine in second and third broods, produced a superior, rich, uniform color, with no spots, staining, dullness or greasiness at harvest. The color and finish on these plots were perhaps the best produced by any of the treatments.

Residue Loads and Removal

Data from six of the most satisfactory and significant treatments are given herewith. All these produced both arsenic and lead loads in excess of the 1934 tolerance.

The heaviest lead load was produced by Oil C, plus lead (all season), the next heaviest by Oil D plus lead. When washed in cold 1.29% hydro-

chloric acid only in a flood type washer without brushes, and running so as to expose the apples to the bath for about 60 seconds only, the lead load from none of the six treatments was reduced below the tolerance, while only three met the tolerance for arsenic. These three were Oil A plus lead all season; Oil E plus lead for first brood followed by Oil E plus nicotine; and Oil A with lead for first brood, followed by Oil A plus nicotine. Oil A with lead was harder to remove than Oil D with lead, but apparently was somewhat easier to remove than Oil E.

When the apples were pre-dipped in 1% cold Vatsol and then washed in 1.29% cold acid, all loads were reduced more than with cold acid alone; but even with the double treatment, only two of the lots met the lead tolerance, namely lead alone and Oil E-lead followed by Oil E-nicotine. The lead loads from all treatments were reduced by the double washing closely enough to the tolerance to indicate that a little further effort, such as heating the bath, use of a brush washer, or a longer bath exposure, would probably have resulted in successful removal in all cases. However, it is obvious that with any schedule calling for a series of strong oil-lead sprays, more complete methods of residue removal must be employed than those used in this case.

Detailed residue loads and removal data are summarized in the following table:

Plot No.	Treatment	Unwashed		Washed in 1.29% HCL.		% reduction lead	Predip vatsol plus 1.29% HCL.		% reduction lead
		Arsenic	Lead	Arsenic	Lead		Arsenic	Lead	
1	Lead-Lime (all season)	.060	.164	.007	.028	83.0	.004	.015	90.8
2	Oil D-Lead-Lime (all season)	.120	.232	.011	.034	85.3	.008	.027	88.3
3	Oil A-Lead-Lime (all season)	.095	.200	.010	.050	75.0	.010	.040	80.0
4	Oil C-Lead-Lime (all season)	.110	.280	.020	.056	80.0	.009	.046	83.5
6	Oil E-Lead-Lime (1st brood) Oil E-Nicotine (later sprays)	.017	.048	.009	.027	43.3	.005	.018	62.5
7	Oil A-Lead-Lime (1st brood) A-Nicotine (later sprays)	.030	.072	.006	.032	55.5	.007	.027	62.5

TEST ORCHARD NO. 2. *Troth-Burton Orchard, Orleans, Indiana*

Varieties treated in the tests here were Rome Beauty and Winesap. The trees are about 30 years old. This large orchard has an extremely heavy codling moth population, and has been one of the very most severely injured in the Central States for some years.

A total of about 8 acres, with 10 different treatments triplicated and randomized on Winesaps and the same 10 treatments duplicated on Rome Beauty, comprised the experimental unit here.

Standard pre-pink, pink, full bloom, calyx, seven day and first cover sprays were applied to all plots, using the same treatment on all. Differing experimental treatments were started with the second cover (first brood) on May 28th. There were 8 sprays of the experimental treatments in all. The first cover, identical on all plots, consisted of Oil E (½%) plus lead (4–100) plus lime, (4–100). Thus, there were 11 codling moth sprays, including the calyx, and nine of them included oil.

In the following table, which summarizes the detailed schedule, beginning with the second cover, the symbols and figures refer to the materials and their concentrations, as explained under Orchard Test No. 1. High calcium spray lime was used in every application where lead was used, in equal amount to the lead.

SPRAY SCHEDULE

Plot No.	First brood		Second brood				Third brood	
	May 28–29	June 8–9	June 20–21	July 5	July 17–18	July 30–31	Aug. 15	Sept. 5
1	L —4	L —3½	L —4	L —4	L —4	L —4	L — 3	L — 3
2	Oil A—1½	Oil A—1	Oil A—1	Oil A—1½	Oil A— 1	Oil A—1½	Oil A—½ L — 3	Oil A—½ L — 3
3	Oil B—1½	Oil B—1	Oil B—1	Oil B—1½	Oil B— 1	Oil B—1½	Oil B—½ L — 3	Oil B—½ L — 3
4	Oil B—1 L —4	Oil B— ¾ L —3½	Oil B— ¾ L —3½	Oil B— ¾ L —3½	Oil B—¾ L — 3	Oil B—½ L —3	Oil B—½ L — 3	Oil B—½ L — 2
5	Oil B—1 NS —1	Oil B— ¾ NS —1	Oil B— ¾ NS —1	Oil B— ¾ NS —1	Oil B—¾ NS — 1	Oil B— ¾ NS —1	Oil B—¾ NS — 1	Oil B—¾ NS — 1
6	Oil B— ¾ NS —1	Oil B— ¾ NS — ¾	Oil B— ¾ NS —1	Oil A— ¾ L —3½	Oil A—¾ L — 3	Oil A— ¾ L —3	Oil A—½ L — 3	Oil A—½ L — 3
7	Oil E—1 L —4	Oil E—1 L —3½	Oil E— ¾ L —3½	Oil E— ¾ L —3½	Oil E—¾ L — 3	Oil E— ¾ L —3	Oil E—½ L — 3	Oil E—½ L — 3
8	Oil E—1 NS —1	Oil E—1 NS —1	Oil E— ¾ NS —1	Oil E—1 NS —1	Oil E—¾ NS — 1	Oil E—1 NS —1	Oil E—¾ NS — 1	Oil E—¾ NS — 1
9	Oil E—1 L —4	Oil E—1 L —3½	Oil E— ¾ L —3½	Oil E— ¾ NS —1	Oil E—¾ NS — 1	Oil E—1 NS —1	Oil E—¾ NS — 1	Oil E—¾ NS — 1
10	Oil B—1 L —4	Oil B— ¾ L —3½	Oil B— ¾ L —3½	Oil B— ¾ NS —1	Oil B—¾ NS — 1	Oil B— ¾ NS —1	Oil B—¾ NS — 1	Oil B—¾ NS — 1

Note.—On plots 2 and 3 the original plan was to use the oils alone at higher dosages throughout, but by the end of July observations indicated that such treatment showed evidence of doubtful results in control, as well as objectionable effects on fruit and foliage. Consequently, the treatment was changed in the last two applications. Likewise, on Plot 6, the original plan was to use a larger number of applications of oil-nicotine, with lower dosages on some sprays. However, it became apparent by the end of the first brood period that codling moth activity and attack were so strong that the required regularly scheduled sprays would have to be spaced so closely that additional applications in Plot 6 could not be made practicably. Hence, the original plan was abandoned, and Oil A plus lead was used the balance of the season.

A constant dosage of materials in each spray was not employed. Instead, the dosage in different applications and in different plots was adjusted to conform to current observational evidence of codling moth activity and control results. For the evidence of moth activity, forming the basis for timing and adjustment of dosages, the writer is indebted to Mr. G. E. Marshall of the Purdue Agricultural Experiment Station and to Mr. Merle S. Troth.

The following table shows a comparison of the average dosages of the various materials on the basis of the entire schedule of eight applications.

AVERAGE CONCENTRATION OF MATERIALS PER APPLICATION

Plot No.	Oil	Lead	Nicotine
1	None	3.66 lbs. per 100	None
2	1.06 Gals. per 100	0.75 lbs. per 100	None
3	1.06 Gals. per 100	0.75 lbs. per 100	None
4	.687 Gals. per 100	3.12 lbs. per 100	None
5	.75 Gals. per 100	None	1.0 pint per 100
6	.687 Gals. per 100	1.91 lbs. per 100	.37 pint per 100
7	.75 Gals. per 100	3.25 lbs. per 100	None
8	.84 Gals. per 100	None	1.0 pint per 100
9	.84 Gals. per 100	1.33 lbs. per 100	.62 pint per 100
10	.78 Gals. per 100	1.33 lbs. per 100	.62 pint per 100

CODLING MOTH CONTROL RESULTS.—The same methods of sampling and recording data on final control results were employed here as in the Ringhausen orchard. Detailed summarization of the data is given in the following table.

WINESAPS

Plot No.	Treatment	% Clean	% Wormy	% Stung	No. stings per 100 apples
1	Lead (all season) Oil A alone (6 covers)	16.1	4.7	83.7	335.0
2	Oil A plus lead (last two) Oil B alone (6 covers)	58.2	8.8	37.7	68.5
3	Oil B plus lead (last two)	61.5	9.1	34.6	62.3
4	Oil B plus lead (all season)	74.6	0.47	24.9	38.2
5	Oil B plus nicotine (all season) Oil B plus nicotine (1st brood)	58.5	4.6	39.5	63.7
6	Oil A plus lead (2nd and 3rd broods)	60.6	3.3	35.4	66.5
7	Oil E plus lead (all season)	49.4	1.3	50.0	100.2
8	Oil E plus nicotine (all season) Oil E plus lead (1st brood)	54.1	5.1	45.3	69.9
9	Oil E plus nicotine (2nd and 3rd broods) Oil B plus lead (1st brood)	48.2	6.4	50.0	99.4
10	Oil B plus nicotine (2nd and 3rd broods)	53.4	4.3	43.7	83.3

ROME BEAUTIES

Plot No.	Treatment	% Clean	% Wormy	% Stung	No. stings per 100 apples
1	Same as on winesaps	1.4	18.2	98.2	572.2
2	Same as on winesaps	70.7	6.1	26.1	40.8
3	Same as on winesaps	65.5	5.9	32.5	56.0
4	Same as on winesaps	75.9	0.9	23.8	34.5
5	Same as on winesaps	50.9	11.8	44.6	68.5
6	Same as on winesaps	55.1	5.4	42.6	80.1
7	Same as on winesaps	28.7	6.0	69.8	161.3
8	Same as on winesaps	57.3	11.5	35.2	52.2
9	Same as on winesaps	46.6	7.7	50.6	105.3
10	Same as on winesaps	56.8	6.6	39.7	67.3

A commercial grade inspection was made of the Winesaps from two of the plots (1 and 4), as representing the poorest and the best control, by Mr. Merle S. Troth, Orchard Manager. It was based on codling moth injury only. The figures are tabulated below:

Treatment	% U. S. No. 1	% Poorer grades (worm injury)	% Poorer grades (sting injury)	% Poorer grades (total)
Lead only (all season)	41.0	5.0	54.0	59.0
Oil B-Lead (all season)	89.27	0.46	10.27	10.73

Here, again, as in the Ringhausen tests, the new oil plus lead throughout the season, produced the most complete control of both worms and stings by a most striking margin. On three varieties, in two orchards, both heavily infested, in no case did this schedule allow as much as 1% worm entrance injury.

Comparison of the percentage of stung apples and particularly of the number of stings allowed by the different treatments again forcibly demonstrates the ovicidal influence of oil, and especially the superiority of the new oil in this respect.

The very large number of stung apples and of stings on the straight lead plots, shows the heavy moth population and attack in this orchard.

SPRAY INJURY—COLOR AND FINISH OF FRUIT

FOLIAGE BURN.—There was no severe burn on any of the plots. The only ones that showed any tendency toward an abnormal burn were plots 2 and 3 (straight oil at high concentrations). This difference was noticeable sufficiently by early August to induce a change of treatment in the last two sprays.

DEFOLIATION.—There was no noticeable defoliation from any treatment. At harvest, the heaviest and greenest foliage was on plots 5 and

8 (oil-nicotine). The next best were plots 9 and 10 (oil-lead early and oil-nicotine late). The lightest foliage was on plot 1 (lead only).

Oil-Spotting of Fruit.—On June 19, the plots being sprayed with oil only or oil-nicotine showed a rather faint to fairly noticeable dark greenish oil-spotting on the fruit. This was most pronounced on plot 8 (paste emulsion plus nicotine). The spotting disappeared gradually, and was not apparent at harvest.

Dullness, Browning or Bronzing

Winesaps.—On parts of plots 2 and 3, the fruit was somewhat dull and lifeless in appearance. Some fruit also showed a sort of browning or bronzing of the skin, as well as a little rougher skin texture. On all other plots, the color and finish were about equal and quite good, considering the seasonal ripening conditions.

Spray deposit color spotting was hardly noticeable, except on plot 7, where it was noticeable, but not severe.

Rome Beauty.—Color was weak on all plots, due to poor ripening conditions.

Plots 2 and 3 showed a considerable amount of dullness, roughness, browning, sunburn and brown enlarged or ruptured lenticels. Plot 2 was worse than 3 in this respect. Others were normal.

Spray deposit color spotting was distinct on plot 7; much less on plot 4; faint on 2 and 3; and lacking on the other plots.

Dwarfing of Fruit.—In mid-season it was felt by some observers that there was a dwarfing effect on plots 2 and 3 (straight oil). Harvest records indicate there may have been a slight effect from these treatments on Winesaps, as plots 2 and 3 averaged 221 apples per bushel, while the average of all other treatments was 198 per bushel. Plot 1 (straight lead) averaged 200 apples per bushel.

On Romes, plots 2 and 3 averaged 188 apples per bushel; all other plots, 208 per bushel; and plot 1 (lead), 428 apples per bushel. There was no evidence of dwarfing by any of the sprays, unless from arsenate of lead. Apple size, on different plots and trees in these tests appears to have been influenced by location, crop load, and tree condition.

Lead Residues and Removal.—Aside from two obvious discrepancies in the results in the case of plot 5 on Winesaps and plot 8 on Rome Beauty, the general trend of results seems to indicate that:

1.—Lead loads were generally greater on Romes than on Winesaps, but the residue appeared to remove more easily from Romes.

2.—While initial load was less where oil-nicotine followed oil-lead, yet the residue from such treatment was harder to remove than from oil-lead throughout.

3.—The new oil-lead residue was easier to remove than the paste emulsion-lead residue.

4.—The washing method employed appears to be reasonably dependable in meeting the lead tolerance in cases of very heavy oil-lead spraying, especially where the new oil is used.

The washing treatment employed was as follows:

EQUIPMENT—(*Tandem*)

1.—Bean Underbrush Pre-dip.
2.—Bean Flotation Washer Model X.

PROCESS

1.—Through Pre-dip, consisting of 2 pounds Vatsol per 100 gallons and 80 pounds B. W. sodium silicate per 100 at 100–104° F. for 45 seconds.
2.—Rinsed.
3.—Through 1.45% H.C.L. @ 62° F. for two minutes.
4.—Rinsed and dried.

The detailed results are given below in terms of lead residue only.

Plot No.	Treatment	Winesaps			Rome Beauty		
		Unwashed	Washed	% reduction lead	Unwashed	Washed	% reduction lead
1	Lead only	.1321	.0430	67.4	.2086	.0007	99.6
4	Oil B plus lead	.1691	.0010	99.4	.2117	.0047	93.3
5	Oil B plus nicotine	.0036	?	?	.0255	.0005	98.0
7	Oil E plus lead	.1840	.0267	85.8	.1562	.0007	99.5
8	Oil E plus nicotine	.0266	.0009	96.6	.0192	?	?
	Oil E plus lead (first brood)						
9	Oil E plus nicotine (later sprays)	.0805	.0156	81.2	.0460	.0275	41.3
	Oil B plus lead (first brood)						
10	Oil B plus nicotine (later sprays)	.0770	.0369	53.2	.0559	.0004	99.2

SUMMARY

A. The new emulsible oils, embodying the principle of chemical treatment to produce distinct modification of the physical properties of the oil, are shown positively in complete 1934 tests to exhibit the following characteristics as compared to former types of oil used in codling moth control:

1. Prolonged surface persistence, superior spreading properties, and improved toxicity.
2. Marked superiority in control of worms and stings, both in combination with lead and nicotine; particularly with lead.
3. More even film coverage and less color spotting than paste emulsions.
4. Oil-lead residue more easily removed than with pastes.
5. Not subject to separation or deterioration in storage and shipment.
6. Contain 95% oil—no water—nearly or quite 100% active insecticidally.
7. Not subject to hard or lime water curdling or similar emulsification difficulties.
8. Easier to pour and measure than paste emulsions.
9. Equally safe on foliage and fruit.
10. Fewer applications and lower concentrations required to produce a given control result.

B. No spray schedule yet developed that will give satisfactory control where codling moth is serious and at the same time make washing unnecessary on late apples.

C. Oil-lead, followed by oil-nicotine, appears to be safe and more effective than lead alone, but is not equal to oil-lead throughout in worm entrance control. This program, however, gives satisfactory control in most cases, reduces the residue load, and has supplementary value in red spider and leafhopper control.

D. Apparently a total of at least 6% oil can be used during the season with lead or with lead and lime without danger of injury.

E. However, it appears to be unsafe to use as much as 6% total oil where any one application consists of 1½% oil or more and where the oil is not combined with lead, lime, or other solids, on susceptible varieties and under unfavorable conditions.

F. Lime may not be required with the new oil-lead sprays to prevent injury, but it is probably advisable to include lime with any oil-lead combination because of the proven fact that lime facilitates residue removal.

G. The new oils plus nicotine are superior in efficiency to former types of oils combined with nicotine, but their margin of superiority used in this way is not so great apparently as when used with lead.

Literature Cited

1. Knight, Hugh, and Cleveland, C. R. Recent Developments in Oil Sprays. Journal of Economic Entomology Vol. 27, No. 1, pg. 269–289, February 1934.

COMMON NAMES OF INSECTS APPROVED BY THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Second Supplement to List Appearing in Volume 24, Pages 1273–1310

A list of 22 common names and suggestions for changing 2 names already approved by the Association was submitted to the active members of the Association for consideration, with the understanding that a name be considered adopted if less than 20 per cent of the votes cast was in opposition. The Committee received votes from 182 members. Thirteen of the new names and one of the changes were approved. The list is given below.

Insects Listed by Scientific Names

Bregmatothrips iridis Watson	Iris thrips
Carpoglyphus passularum Her.	Dried fruit mite
Cnephasia longana Haw.	Strawberry fruit worm
Ephestia elutella Hbn.	Tobacco moth
Gnorimoschema lycopersicella Busck	Tomato pinworm
Heteroderes laurentii Guer.	Gulf wireworm
Loxostege commixtalis Walk.	Alfalfa webworm
Paratetranychus citri McG.	Citrus red mite
Paratetranychus yothersi McG.	Avocado red mite
Phenacoccus gossypii Towns. and Ckll.	Mexican mealybug
Scirtothrips citri Moult.	Citrus thrips*

*Changed from orange thrips.

Tarsonemus approximatus narcissi Ewing.	Bulb scale mite
Tetranychus sexmaculatus Riley	Six-spotted mite
Vitula serratilineella Rag.	Dried fruit moth

INSECTS LISTED BY COMMON NAMES

Alfalfa webworm	Loxostege commixtalis Walk.
Avocado red mite	Paratetranychus yothersi McG.
Bulb scale mite	Tarsonemus approximatus narcissi Ewing
Citrus red mite	Paratetranychus citri McG.
Citrus thrips	Scirtothrips citri Moult.
Dried fruit mite	Carpoglyphus passularum Her.
Dried fruit moth	Vitula serratilineella Rag.
Gulf wireworm	Heteroderes laurentii Guer.
Iris thrips	Bregmatothrips iridis Watson
Mexican mealybug	Phenacoccus gossypii Towns. and Ckll.
Six-spotted mite	Tetranychus sexmaculatus Riley
Strawberry fruit worm	Cnephasia longana Haw.
Tobacco moth	Ephestia elutella Hbn.
Tomato pinworm	Gnorimoschema lycopersicella Busck

Scientific Notes

***Hyperplatys asperus* Say[1] attacking peach.** Specimens of this species were collected in dead and dying peach wood on the farm of A. G. Lewis, Geneva, N. Y., during the winter of 1934–35. The trees had been severely injured by sub-zero temperatures during the previous year. Infestation was general thruout a block of some 10,000 trees. Material was collected in the larval stage (hibernating) and incubated in the laboratory so that adults emerged during January, 1935. All of the trees attacked had been hopelessly winter-injured and were removed during the winter of 1934–35, therefore no other control measures were necessary. This constitutes the first record of injury to peach by this species, altho its recorded hosts are many and it is probable that almost any tree would be attacked if in a severely weakened condition.

D. M. DANIEL, *Experiment Station, Geneva, N. Y.*

Phenothiazine, a Promising New Insecticide. In the search for new synthetic insecticides many organic compounds have been prepared by members of the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine. One of these materials, phenothiazine, was found to be more toxic than rotenone when tested against mosquito larvae (*Culex quinquefasciatus* Say).[2]

Phenothiazine is prepared by fusing 1 part of diphenylamine with 2 parts of sulphur at 180° C., using iodine as a catalyst. After recrystallization from toluene it is a light yellow crystalline compound melting at 180° C. It is neutral material, insoluble in water and, in the cold, only slightly soluble in mineral oils and the usual organic solvents.

Preliminary laboratory tests of phenothiazine against codling moth larvae (*Carpocapsa pomonella* L.) were made in April 1934. The results obtained justified its trial in the field. The commercial material employed in field tests, however, was later found to be only approximately 55 per cent phenothiazine (the remaining 45 per cent being nontoxic), and so the results obtained with this material were not conclusive. Further chemical studies on the preparation of phenothiazine have been made and at the present time a very pure product is available commercially in limited quantities. Additional laboratory tests of the chemically pure phenothiazine against codling moth larvae indicate that the material is fully as effective as lead arsenate.

[1]Identification confirmed by Mr. W. S. Fisher of the National Museum.
[2]Campbell et al., Jour. Econ. Ent. 27 : 1176–1185. 1934.

The material is being tested by various divisions of the Bureau of Entomology and Plant Quarantine against insect pests of economic importance.

L. E. SMITH, *Division of Insecticide Investigations*, and F. MUNGER and E. H. SIEGLER, *Division of Fruit Insect Investigations, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture*

Aluminum Sulfate as a Sticker for Hydrated Lime in Sprays. In the course of laboratory experiments to obtain a sticker for hydrated lime sprays to control injury caused by the Japanese beetle, it was found that small quantities of aluminum sulfate gave excellent results. When aluminum sulfate is dissolved in water the solution has an acid reaction, and upon the addition of hydrated lime, calcium sulfate and aluminum hydroxide are formed. The calcium sulfate is slightly soluble in water but is dissolved with difficulty once it has dried. The aluminum hydroxide, when precipitated, is sticky and gelatinous, but upon drying it is hard and firm. The hydrated lime itself, which would be in excess in the spray combination, is white, the aluminum hydroxide nearly so, and the calcium sulfate is white when dry. Since a white residue repels the Japanese beetle, this combination seemed to have possibilities for use in the field. For this purpose the spray tank was gradually filled with water; when it was one-quarter full the aluminum sulfate was added, when half full the hydrated lime was added slowly, and when the tank was completely filled the mixture was ready for immediate use. Good results have also been obtained by dissolving the aluminum sulfate in 2 gallons of water in a pail and pouring this solution into the mixture produced by adding the hydrated lime to the water in the tank, while the latter was being filled.

The combination of 20 pounds of hydrated lime and 3 pounds of aluminum sulfate per 100 gallons of water proved satisfactory in three orchards in New Jersey during 1934, the residues being quite permanent and water-resistant. One block of early peaches was sprayed with this combination four times over a period of 5 weeks and 6 weeks after the last application, although heavy rains had fallen in the meantime, the residue was still very prominent. The residue from an equal quantity of hydrated lime, either alone or with either 3 pounds of flour or 1 pint of Menhaden oil, did not remain prominent for this length of time.

It is believed that, since the use of aluminum sulfate gave good results with hydrated lime alone, it may be of value in conjunction with other sprays of which hydrated lime is an essential ingredient, particularly those to which expensive materials are now added to make the residue adhere to the foliage.

J. W. LIPP and M. R. OSBURN, *Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture*

Effect of Paraffin Wax Emulsions on the Oil-Depositing Properties and Insecticidal Efficiency of Oil Sprays. In May, 1934, the writer found that if citrus trees are sprayed with paraffin wax emulsions before being sprayed with oil, the deposit of oil and insecticidal efficiency of the spray are greatly increased. It was subsequently found, however, that if the wax emulsions are poured in the spray tank with the oil, the same effect is obtained and only a single application of spray is required. This led to further experimentation which in every case substantiated the preliminary observations.

Paraffin wax (M. P. 47–49° C) was emulsified with triethanolamine stearate or triethanolamine oleate prepared in the laboratory. Melted wax was added to water near the boiling point, which contained the emulsifier, and the resulting mixture was stirred with a paddle, or forced through a spray pump, while cooling. The resulting emulsions contained about 30 per cent, by weight, of wax, the remainder being water and emulsifier. Spermaceti wax (M. P. 44° C) was found to be as satisfactory as paraffin wax. In either case the emulsified wax forms a colloidal suspension when diluted with water. The wax particles range in size from barely visible with the high power of the microscope to 2 microns in diameter.

An experiment on the effect of wax emulsions on oil spray involved the examination of 172,878 California red scale on the branches of lemon trees sprayed with various concentrations of Grade 5 (heavy) spray oil with and without various concentrations of wax emulsion added to the oil spray. It was found that wax emulsions ranging in concentrations from ⅛ to 1 per cent of the spray mixture increased the

amount of oil deposited and greatly increased the percentage of insects killed by the spray. Usually the survival of insects from treatment by any given percentage of oil was reduced about one-half by the addition of ⅔ to 1 per cent of wax emulsion to the oil spray. Moreover, for any given deposit of oil, the oil sprays to which wax emulsion had been added effected a greater kill of the insects than did oil sprays without wax emulsion.

The wax emulsions have shown no perceptible injurious effect on citrus trees at as high as 5 per cent concentration. The wax is apparently not absorbed by the foliage. It is believed that the wax is not absorbed by the foliage or rough bark of the tree even when added to an oil spray, but accurate analyses for wax in the residue extracted from the leaves by ether will have to be made to definitely determine this point.

Experiments are being continued along the line indicated. Emulsions are being made of wax and oil in combination. In these, 20 per cent of the emulsion is water and emulsifier. These emulsions appear to give about the same results per cubic centimeter of oil deposited as when the oil and wax are poured into the spray tank separately, but they break readily in hard waters. Attempts are being made to overcome this undesirable feature of the wax-oil emulsions.

WALTER EBELING, *University of California Citrus Experiment Station, Riverside, Calif.*

Economic Injury to Beans from the Activities of the Mason Bee *Osmia pellax* Sandhouse. On June 18, 1934, our attention was called to a severe case of defoliation injury to Great Northern beans on a ranch 1 mile east and 4 miles south of Kimberly, Idaho. Upon investigation it was found that approximately 4 acres of a large planting were heavily infested with a mason bee, *Osmia pellax* Sandhouse,[1] which had practically defoliated every plant within the infested portion of the field. With the exception of the midvein, the entire leaf was often removed from the plant. Unlike the true leaf-cutting bees, *Osmia* did not cut out circular portions of the leaf but, rather, chewed it up as it went along, as is the habit of a typical leaf-feeding caterpillar. These activities often involved the destruction of the leaf, and in some cases the plants were completely defoliated.

A review of the literature on *O. pellax* by Miss Mabel Colcord, Librarian of the Bureau of Entomology and Plant Quarantine, failed to reveal any records of the habits of the species, or of damage caused by it. Miss Colcord found that the species was originally described by Miss Grace Sandhouse on the basis of specimens collected by M. P. Van Duzee, June 6–12, 1924, at Keen Camp, Riverside County, Calif. Essig[2] says (of the Megachilidae): "This large family has many representatives in the Western States, but there is little exact information regarding their habits. Most species pollinate plants and the great good they do in this way far outweighs the slight damage in cutting the leaves of plants." More is known, however, about European species.

Close observation of the activities of the bees in the affected field showed that the chewed-up leaf material was being held between the forelegs in the form of a small, tightly-wadded ball. When the bee had secured a sufficient load, it took flight from the field to its nesting area, flying but a few feet above the surface of the ground. It was later found that the material was being used as a "plaster" for lining the underground egg cavities, just as some other species of the group employ bits of gravel cemented together for the same purpose.

By following the line of flight of the bees to and from the infested field, the nesting site was located about one-eighth of a mile away on a dry and non-irrigable lava outcrop, lying above the "high-line" irrigation ditch. The soil in this location was very dry and rocky and covered by downy brome grass (*Bromus tectorum* L.) with a few scattered plants of sagebrush (*Artemisia tridentata* Nutt.) and Russian thistle (*Salsola pestifer* A. Nels.).

[1]The determination of this species of Megachilidae (order Hymenoptera) was made by Miss Grace Sandhouse, of the Division of Insect Identification of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, and she has furnished the writers with references and notes on the habits of European species. The original description is found in Proc. Calif. Acad. Sci. Series IV : 13: (22) p. 356, 1924.

[2]1926. Insects of Western North America. McMillan Co., New York, pp. 1035 + lx (pp. 893–895)

It was found that this species nests in holes which extend between 1.2 to 3.2 inches below the surface of the soil. The average vertical depth of the holes, however, was 1.2 to 2 inches. The tunnels, which averaged about 3 inches long, slanted from the horizontal and often made a variety of turns before ending in a slight enlargement containing the egg capsule, which was constructed from the macerated leaf material. The bees constructed these tunnels by breaking off portions of soil with their mandibles. The larger particles seemed to be carried by the mandibles while the finer material was dragged out by the clypeus and labrum. The bees entered the holes crawling forward, and emerged backing out with the head bent downward so as to form a drag-like arrangement with the clypeus and labrum. Several specimens were collected and examined under the microscope for dirt stain. The inside of the mandibles and underside of the clypeus and labrum were in several cases thickly coated with dirt. The field in which these tunnels were made was literally honeycombed with them. Counts made on some of the more densely populated spots showed tunnel openings numbering from 16 to 22 per area 6 inches square.

Upon the completion of the excavation, a capsule, composed principally of macerated bean leaf, was built within the enlarged terminal portion of the tunnel. Apparently only one bee was concerned with the construction of each nest and ordinarily but one egg capsule occurred. In a few cases, however, additional capsules were found leading off the same tunnel, three being the maximum number observed.

The capsules, which were ovate and averaged about 0.6 by 0.2 inch, appeared to be composed entirely of macerated bean leaf and some secretion used to weld the material together. A drop of honey-like substance approximately 0.25 inch in diameter, upon which was laid a single egg, was deposited in the bottom of each finished capsule. The honey-like substance contained pollen, which, as nearly as we could determine, came from sweetclover and alfalfa. This determination checked well with observations on the feeding of the insect made in the field. The bees were observed feeding on the flowers of white sweetclover, yellow sweetclover, and alfalfa. The white sweetclover appeared to be the most favored of these three plants.

In attempts to curb the ravages of the bees, the bean plants in the borders of the injured portion of the field were sprayed with lead arsenate and the soil of the nesting site was broken up with a disc and spring-tooth harrow. No definite data could be obtained, however, concerning the control values of either of these treatments although a large portion of the egg capsules was destroyed by the mechanical treatment.

At harvest, it was estimated that the yield in the damaged part of the field had been reduced by one-third. The affected plants had recovered from the injury caused by the bees and had resumed normal growth, but they were retarded two or three weeks in their development.

ROBERT A. FULTON, *Associate Entomologist*, and H. G. BERGEN, *Assistant Field Aide, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture*

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

AUGUST, 1935

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $3.50 per page. There is a charge of $3.50 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

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A. A. A. S. Winter meetings, December 1935, St. Louis; December 1936, Washington; December 1937, Indianapolis, Ind. Summer meetings, 1935, Minneapolis; 1936, Rochester, N. Y.; 1937, Denver, Colo.

The recent allotment of $2,500,000 for Dutch elm disease work is gratifying news to those interested in tree welfare. This fund makes possible the continuance of an important project which has suffered greatly in the past from inadequate appropriations. In this connection it may be well to mention the sums alloted by the advisory committee on the Federal Works Program, and listed elsewhere, for barberry eradication, peach mosaic control, white pine blister rust control, gipsy moth control, citrus canker eradication, brown-tail moth control, phony peach disease control and eradication of the wild host plant of the thurberia weevil, the total for all these projects, including the Dutch elm disease, amounting to $16,213,118. This seems like a large amount, and yet, when due allowance is made for the injurious or destructive potentialities of these insects and diseases, the sums are by no means excessive, and they afford an opportunity, possibly not otherwise obtainable, for demonstrations of the possibilities of what may be termed large scale control.

The extreme abundance of the apple tent caterpillar in eastern United States aroused general interest in the problem of control, mostly too late for effective action, and in some cases has resulted in ill advised recommendations or action. The latter is strikingly illustrated in a recently adopted village ordinance in south-eastern New York. A part of the text follows: "It shall be unlawful for any owner of any occupied or unoccupied lot or land or any part thereof * * to permit or maintain on any such lot or land, any trees, shrubs or bushes or parts thereof which are or may become infected or infested with caterpillars, tent-caterpillars, insects, worms, maggots, parasites, larvae or grubs of lepidopterous insects or other creeping segmented animals, which cause

or tend to cause disease, destruction or damage to such trees, shrubs or bushes by devouring the bark or foliage thereof, and which spread by passing from such trees, shrubs or bushes, to other trees, shrubs or bushes, thereby causing destruction and damage to the property of others and becoming an unsightly and a public nuisance." Those not complying with the ordinance are decalred guilty of disorderly conduct, and upon conviction are liable to a fine not exceeding $100 for each offense, each day upon which such violation continues constituting a separate offense. This act is both comprehensive and drastic. There is no question but that this goes altogether too far in attempting to provide for insect control through legal enactment.

Current Notes

Dr. W. W. Yothers retired May 31 from the Bureau of Entomology after thirty years of Government service. He was associated for three years with the Boll Weevil Investigations and subsequently has been in charge of the investigation of problems connected with the pest control on citrus trees conducted at the Bureau of Entomology Laboratory, Orlando, Florida. He is now engaged in commercial work along these lines.

The Seventh American Scientific Congress is to be held in Mexico City, September 8th to the 17th. The Mexican Government has invited the United States Government to appoint official delegates and requested that the meeting of the Congress be brought to the attention of the universities, learned societies and scientific organizations of the United States. Mr. Lee A. Strong, President of the American Association of Economic Entomologists has designated Dr. A. C. Baker, one of the Bureau men located in Mexico City, as the official representative of the Association. It is hoped that American entomology may be well represented at this Congress.

Horticultural Inspection Notes

The Advisory Committee on allotments for the Federal works program, on July 1, announced the approval of work relief allotments of $2,376,920 for barberry eradication, $47,920 for peach mosaic control, $6,378,735 for white pine blister rust control, $2,800,000 for gypsy moth control, $140,500 for citrus canker eradication, $970,000 for brown-tail moth control, $831,568 for phony peach disease control, and $167,475 for the eradication of the wild host plant of the Thurberia weevil.

Co-operative Federal and State inspection for the phony peach disease is now under way in the southern states, growers furnishing the labor to dig up and remove all infected trees as located by the inspectors. Inspection will be made of commercial orchards and the environs of nurseries in all infected states. In addition to the intensive inspection in the known infected commercial areas of the lightly infected states, a general survey is being made of other parts of these states as well as Delaware, New Jersey, Maryland, Virginia, West Virginia, Ohio, Indiana, and Kentucky. None of the latter is known to be infected.

Two air-mail shipments of uncertified cut flowers originating in an area infested with the Japanese beetle and consigned to points in Indiana and Missouri were recently intercepted by Federal transit inspectors at New York City.

J. W. Patterson, Assistant Plant Quarantine Inspector in the Bureau of Entomology and Plant Quarantine, is being transferred from the Mexican fruit fly project to plant quarantine inspection at St. Paul on July 15.

For the reason that "insect or other closely related animal pests, poisonous or injurious plant or plant diseases are likely to be introduced into Wyoming by the importation of farm products or other objects," the Commissioner of Agriculture of that state placed a quarantine, effective July 1, declaring that "farm products or other objects" may not enter Wyoming from other states except as follows: Hay or straw or their products and agricultural and garden seeds may enter when certified as to complete absence of seeds of "all primary perennial noxious weeds" and, in the case of hay, absence of parts of such weeds. Nine plants are designated as such weeds.

Recent quarantine action relating to the potato tuber moth has been taken by officers of Alabama, Tennessee, and Michigan. The Alabama quarantine established on May 30, requires that all seed Irish potatoes coming from Florida must be certified at origin, shipped in June, and held in cold storage until July 5. The Tennessee quarantine, effective May 15, applies to potatoes for seed or food and requires certification when shipped from California, Florida, Iowa, Louisiana, Maryland, North Carolina, South Carolina, Texas, Utah, and Virginia. The Michigan regulations relating to the moth were extended June 1 to include the states of Louisiana, Maryland, North Carolina, South Carolina, and Tennessee. The infested states as listed in the former Michigan quarantine, are California, Florida, Texas, and Virginia.

The Oregon quarantine order relating to the vegetable weevil in California was reissued on May 29 to provide for the acceptance of the host plants when certified as produced in an area free from the weevil.

Effective April 11, the Utah State Board of Agriculture placed a quarantine against the tomato pinworm which restricts the entry of tomato plants from California, Pennsylvania, Delaware, Missouri, and the west coast of Mexico, unless certified as free from the worm and also free from certain noxious weeds.

The alfalfa weevil quarantines of Illinois and Michigan, as reissued in May, bring under restriction San Juan County, Colorado, and place no restrictions on Union County, Oregon. The Illinois quarantine removes Nebraska from the regulated area, while the Michigan quarantine includes it. Both states provide for entry of alfalfa hay from December 1 to March 15 when chopped and blown into the car by a blower making 2,100 revolutions per minute.

Fertilizers and stock feed containing over 25 per cent of cotton seed meal are not allowed to enter Puerto Rico if mixed in any one of the 16 states named as infested with the cotton boll weevil, according to Puerto Rican quarantine No. 11, promulgated May 10, 1935.

Professor A. E. Stene, State Entomologist of the Rhode Island Department of Agriculture reports there has been a complete reorganization of the state government of Rhode Island. All departments, bureaus and commissions which have developed through many decades of legislative work have been abolished and the government has been organized into eleven departments, four of which are directly under the Governor and seven of which are headed by a director. The former Department of Agriculture has become the Department of Agriculture and Conservation with four divisions. The insect and plant disease work is under a division called the Division of Plant Diseases and Dangerous Insects with former Senator John J. Barry as Chief. Harry Horovitz, formerly superintendent of field work and A. W. Hurford, blister rust agent, have severed connections with the work and their places have been taken by Mr. Alvin Lannon and A. C. White.

Twelve inspectors were employed under the direction of E. C. Mandenberg, In Charge of Orchard and Nursery Inspection, on inspection activities for the Michigan Department of Agriculture this summer. These include: C. A. Boyer, William Whitbeck, Harold Kiebler, O. K. White, Francis Meiers, William Knowlton, John Prillwitz, Sidney Davis, Guy Coffing, Leland Small, L. E. Landon and John Garver.

A letter of information was sent out to all Ohio nurserymen this summer by W. W. Ellenwood, Chief of the Division of Plant Industry of the Ohio Department of Agri-

culture, along with their application blank for nursery inspection. This letter, besides advising of the general regulations, contained abstracts of new regulations and warned against certain pests liable to be serious during the summer and offered methods for their control.

One larval specimen of alfalfa weevil was reported discovered in Scotts Bluff County, Nebraska in July and seven in Sioux County of the same state by Ralph Bunn, Junior Entomologist of the Federal Bureau of Entomology and Plant Quarantine. A public hearing was scheduled on August 5 at Gering, Nebraska to consider the advisability of promulgating an intrastate quarantine covering these counties, according to L. M. Gates, Entomologist of the Nebraska Department of Agriculture and Inspection.

White Pine Blister Rust control agents of the Lake States held a conference in Milwaukee, Wisconsin, on July 19–20 to lay plans for carrying out a project under the Works Program administration funds. Representatives were present from Minnesota, Michigan, Ohio, Iowa, and Wisconsin.

E. M. Woolverton and C. P. Shumway are the latest additions to the nursery inspection staff in Minnesota, according to A. G. Ruggles, State Entomologist of the Minnesota Department of Agriculture and Dairy and Food. Mr. Shumway is taking work for his doctor's degree in the Division of Plant Pathology.

The fourteenth annual meeting of the International Great Plains Conference of Entomologists was held this year at Custer State Park, near the Game Lodge, in South Dakota, on August 1 and 2. Professor A. G. Ruggles, State Entomologist of Minnesota, was chairman. This was the second consecutive year the meetings were held on this side of the international line. Last year the meeting was held at Lake Itasca in Minnesota.

A Revision of California's Quarantine Proclamation No. 16, effective July 31 pertaining to the Colorado potato beetle provided two modifications. According to A. C. Fleury of the California Department of Agriculture, tomato plants and egg plants are now permitted entry from other states when certified as having been growing in a Colorado potato beetle free district. Presence of portions of potato plants will not result in rejection of potatoes from such areas.